Hydroacoustic Assessment of Downstream Migrating Salmonids at The Dalles Dam in Spring and Summer 1985

Final Report

by

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TABLE OF CONTEXTS

TABLE OF CONTENTS (cont.)

LIST OF FIGURES

LIST OF FIGURES (cont.)

LIST OF FIGURES (Cont.)

List of Appendix Figures

LIST OF TABLES

LIST OF APPENDIX TABLES

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EXECUTIVE SUMMARY

From April 22 to August 15, 1985, Biosonics, Inc. conducted a hydroacoustic study of downstream migrating salmon and steelhead at The Dalles Dam. The primary objective of this study was to estimate the effectiveness of the spillway and sluiceway in passing downstream migrants. The secondary goals of this study were to provide information on the horizontal, vertical, and temporal distributions of downstream migrants. The study was separated into two periods. The spring season was from April 22 to June 1, and the summer season was from July 1 to August 15, 1985. Nineteen transducers were deployed to monitor turbine, spillway, and sluiceway locations.

The 10 h instantaneous spill effectiveness results showed that spill passed fish more efficiently during the summer study than during the spring study. Respective Spill levels of 17.8% and 21.8% for summer and spring results in summer and spring Spill effectiveness estimates of 39.9% and 23.2%, respectively.

During the period May 1-31 when the turbines, spillway, and sluiceway were all operating consistently, the sluiceway was found to be the most efficient method of passing fish on a percent flow basis. Sluiceway fish passage was 23.2%, using an average of only 1.6% of the total average river (mean 24-h average). At the turbines, 67.7% of fish passed in 88.1% of the river flow. At the spillway, 9.2% of the fish passed in 10.3% of the river flow. During this period, the spillway was operated 10 h a day (0900-1900 h) and the turbines and sluiceway were operated 24 h a day. The comparisons are all 24 h average results.

During the summer study, after the termination of spill (July 11 to August 14), the sluiceway and turbines passed almost equal percentages of fish. The mean percent passage for the sluiceway and turbines for this period was 48.7% and 51.3%, respectively. Water flow into the sluiceway averaged 3.7% of the daily average river flow while the turbines used 96.3% of the daily average flow.

The run timing during the spring study showed steadily increasing numbers of fish until the peak of the run on May 16. Another, smaller peak occurred on May 20. Thereafter, passage gradually decreased through the end of the spring study. The spring run consisted of yearling chinook, steelhead and sockeye juvenile salmonids. During the summer study, fish passage gradually decreased, except for minor peaks near the beginning of the study. The summer migration consisted primarily of subyearling chinook juvenile salmonids.

The vertical distributions of fish passage at the powerhouse showed that the fish were significantly higher in the water column during the daytime than at night for both the spring and summer studies. There was also a difference in distribution between the spring and summer studies with the summer migrants lower in the water column at both the powerhouse and spillway.

From May 7 to May 31 in the spring study, the average hourly fish passage for individual locations (turbines, sluiceway, and spillway) showed relatively higher passage during nighttime hours at the powerhouse. The sluiceway fish passage peaked near dawn (0400 h) following a drastic drop in fish passage at the powerhouse. This pattern of fish movement is very likely caused by both the increase of fish activity at dawn accompanied by a dramatic shift in the migrant vertical distribution.

From July 11 to August 14 in the summer study, average hourly fish passage at the turbines was relatively constant, with an evening peak around 2000-2200 h. Fish passage at the sluiceway was also relatively constant until 1900 h (the last hour of sluiceway operations) when a large peak occurred.

During the 40 d spring study, an average of 56.0% of the fish passed during the 14 h daytime (i.e., 58% of the 24 h) and 44.0% passed during the 10 h nighttime (42% of the 24 h). In contrast, during the 45 d summer study, an average of 69.6% of the fish passed during the daytime and 30.4% passed during the nighttime.

The daytime/nighttime results showed that during the spring study the fish passed continuously throughout the 24 h period in contrast to the summer study when the fish passed primarily during the daylight hours. This change in the diel distribution during the summer season could have contributed to the increase in the effectiveness in the summer daytime spill.

During the spring study, the horizontal distribution of fish across the powerhouse showed the most fish passing through Turbine Unit 3 and the least through Unit 22. In contrast, Units 3 and 22 passed nearly equal percentages of fish during the summer study. The smaller subyearling chinook passing during the summer season were believed to be more shore-oriented. This could have contributed to the greater percentage of summer fish passing through Unit 22, which is nearest the south shore of the river.

Many factors could have contributed to these differences between spring and summer. The summer season consisted primarily of subyearling chinook smolts, while the spring season consisted of chinook yearlings, steelhead and sockeye smolts. The magnitude of the spring run was greater than the magnitude of the summer run. Also, the river flow during the spring was as much as three times greater than the flow past the project during the summer.

This year's baseline study provided valuable insights into the horizontal, vertical, and temporal distributions of downstream migrants. It has also provided information on the effectiveness of passing fish through the spill and sluiceway. However, at other Columbia River dams there has been a large variability in the distribution and migration patterns of fish from year to year. It is recommended that further studies be performed to provide more information for different years.

The vertical distributions showed that the fish were deeper in the water column at night. Since the spillways open from the bottom upwards, this suggests that nighttime spill might be more efficient than daytime spill. This suggestion is supported by results of the summer study, where spill effectiveness increased as vertical distributions shifted deeper in the water column. It is recommended that a nighttime spill schedule be included in further studies.

To better characterize the relationship between percent river spilled and percent fish passing in spill, a wide range of controlled spill levels should be tested. A 5 d spill block (with 5 different spill levels) repeated through the course of the study would allow evaluation of spill effectiveness at different spill levels, independent of seasonal factors.

The "in-season" index proved reasonably effective for tracking major trends in the migration. An in-season real-time index could be an effective management tool.

Finally, to better define the most efficient spill pattern, the use of fewer spill gates opened wider is recommended. As found at other Columbia River dams, spill effectiveness can be increased by a change in the spill gate operation.

1.0 INTRODUCTION

1.1 Background

Since the early 1950s, the salmon and steelhead runs on the Columbia and Snake rivers have declined due to several factors, including the construction and operation of hydroelectric dams. Most downstream migrating juveniles pass safely through the turbines at any one Columbia River dam. But fish may pass through many dams before reaching the Pacific Ocean, and cumulative mortalities can be substantial (Bellet al. 1967, Davidson 1965, Schweibert 1977).

In the last decade, considerable effort has been expended exploring ways to restore and enhance these fish runs. Most of this effort has been directed by the Federal Energy Regulatory Commission and the Northwest Power Planning Council. The Bonneville Power Administration and the u. S. Army Corps of Engineers are currently evaluating bypass methods to increase the survival rate of downstream migrants as they pass the various dams while minimizing adverse effects on power production. For this reason, the BPA contracted with BioSonics, Inc. to conduct hydroacoustic studies at The Dalles and Lower Monumental dams. This report contains the results of the 1985 study at The Dalles Dam.

1.2 Study Objectives

specific objectives for the 1985 study at The Dalles Dam, in order of priority, were to estimate:

1) the effectiveness of the spillway and sluiceway for passing downstream migrants;

2) daily and cumulative run timing of fish passage through the project;

3) diel passage rates of downstream migrants through powerhouse, spillway and sluiceway;

4) the proportions of migrants that passed through each turbine intake and spill bay (i.e., the horizontal distributions across the powerhouse and the spillway); and

5) the vertical distributions of migrants approaching turbine intakes and spill gates.

1.3 Site Description

The Dalles Dam is located near the city of The Dalles, Oregon at river mile 192 on the Columbia River (Figure 1). It lies between Bonneville and John Day Dams. The dam impounds the 24 mile long Lake Celilo and releases water into Lake Bonneville, both of which may experience daily fluctuations of up to 5 ft. The dam is 8700 ft long. Its "L" shaped configuration has 23 spill gates perpendicular to river flow (running north-south), and the powerhouse runs east to west near the southern (Oregon) bank, Parallel to river flow (Figure 2). The Dalles Dam has the third largest power generating capacity on the Columbia/Snake River system, with 1807 MW.

The powerhouse is 2089 ft long with 22 main generating units (numbered from west to east), 2 auxiliaries units and 2 station service units. Each turbine has three intake galleries. The intake galleries are 20 ft wide and 43 ft high (Figure 3).

The ice and trash sluiceway has 3 surface intake gates above each of the turbine intake galleries. Each sluicegate is 20 ft wide and can allow Io-15 ft of surface flow (depending on forebay pool level) to pass through each gate. The hydraulic capacity of the sluiceway allows for a maximum of three open gates at any one time. During this study, only the three sluice gates at unit 1 were operated (Figure 3).

The spillway has 23 gates numbered north to south. The gates are 50 ft wide and extend down 42.5 ft to the seal. Each gate can be raised more than 40 ft (Figure 4).

1.4 species

The common and scientific names of juvenile salmonids passing The Dalles Dam are:

Chinook salmon	_onchorhynchus tshawytscha_
spring chinook yearlings	
fall chinook subyearlings (0 age)	
Sockeye salmon	_O. nerka_
Coho salmon	_O. kisutch_
steelhead trout	_Salmo gairdneri_

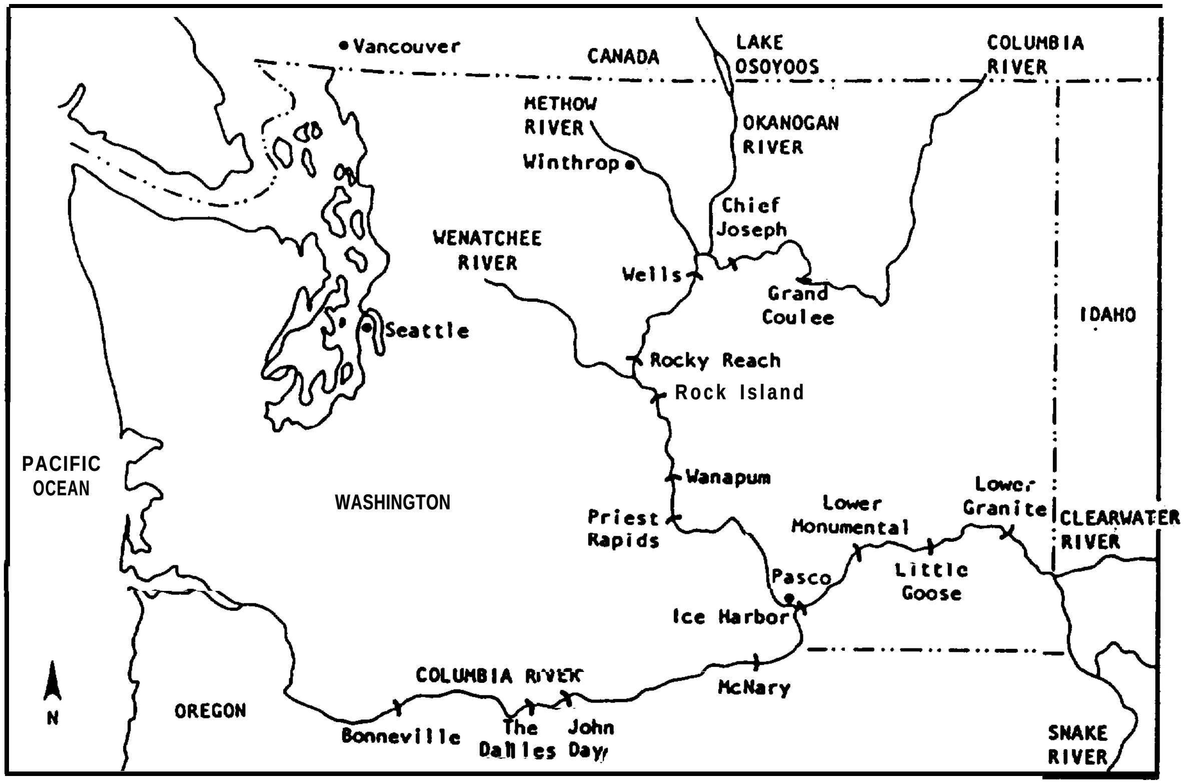

Figure 1. Location of The Dalles Dam on the Columbia River.

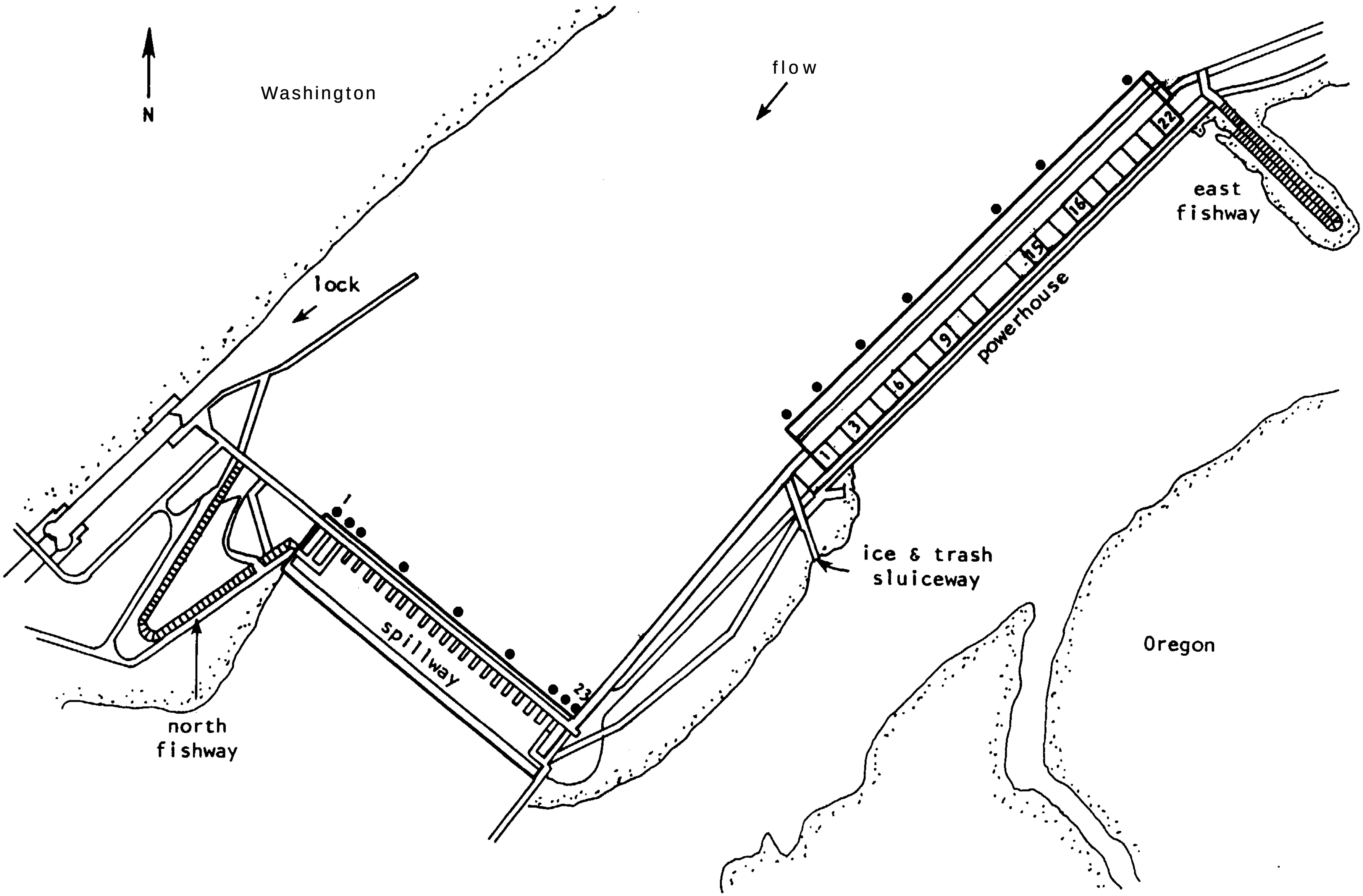

Figure 2. Plan view of The Dalles Dam showing transducer locations used in 1985.

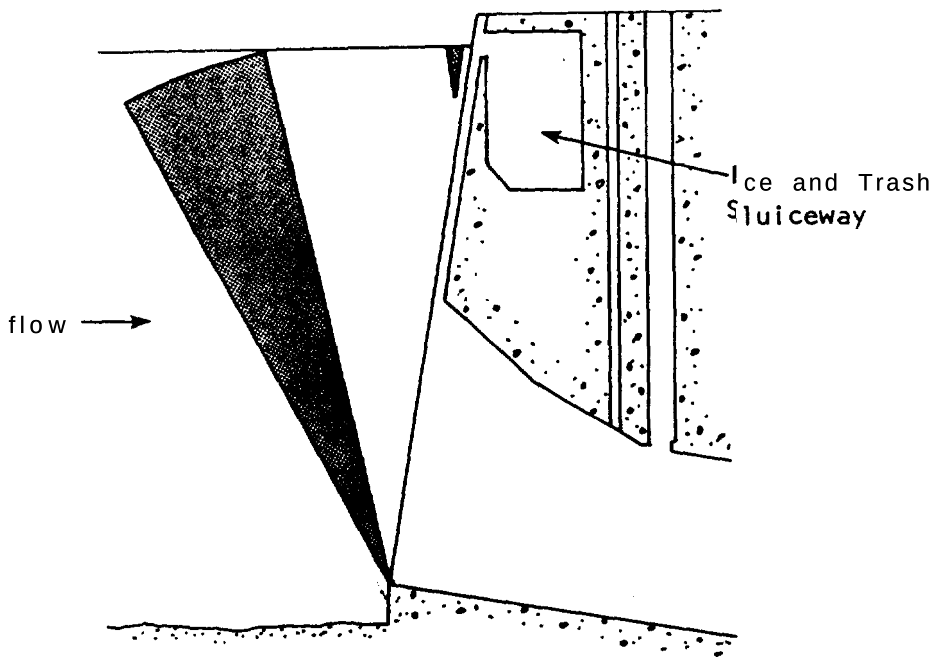

Figure 3. Cross section of the powerhouse showing transducer location and orientation. The Dalles Dam, 1985.

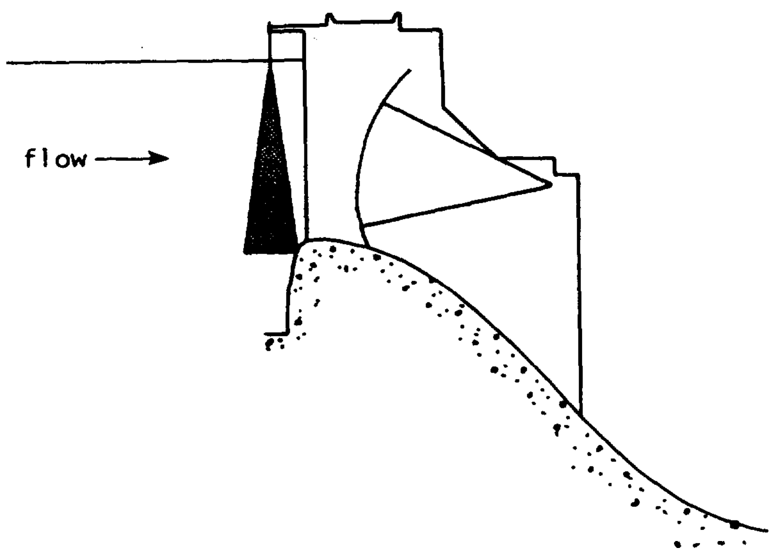

Figure 4. Cross section of the spillway showing transducer location and orientation. The Dallas Dam, 1985.

2.0 GENERAL METHODS

2.1 Equipment and Operation

Over the last several years, hydroacoustic technology has been developed to allow accurate measurements of fish abundance, distribution, and behavior (Burczynski 1979, Wirtz and Acker 1979 and 1980). At Columbia and snake river dams, hydroacoustics has proven to be an accurate technique for monitoring the movements of downstream migrants (Carlson 1982a, 1982b, 1982c; Carlson et al. 1981; Dawson et al. 1982; Dawson et al. 1984; Gyldenege et al. 1983; Karp et al. 1982; Karp et al. 1984; Raemhild et al. 1983; 1984a; 1984b; 1985a; 1985b; 1985c). At The Dalles Dam, hydroacoustic monitoring of downstream migrants was done by Magne et al. (1983).

Calibration and operation of the hydroacoustic systems used at The Dalles Dam are described in Appendix A.

2.2 Data Collection, Storage, and Analysis

Fish passage at the powerhouse, spill and sluiceways were monitored continuously throughout the spring study period from 0800 h on April 22 through 0800 h on June 1, and during the summer study from 0800 h on July 1 through 0800 h on August 15. Transducers were oriented to detect migrants passing the dam. At the powerhouse, the center slots of Turbine units 1, 3, 9, 13, 16 and 22 were sampled, as were spill Gates 1, 2, 3, 7, 12, 17, 21 and 23, and the ice/trash sluice Gates I-I, 1-2 and l-3 (see Figures 3 and 4). Transducers were also located at Turbine unit 6 and Spill Gate 22, but their data were eliminated from the data analysis as they failed during the study. Each "day's" sample period began at 0800 h and included 0000-0800 h of the next day. All times reported are in Pacific Standard Time (PST).

The 40 d spring study was divided into eight 5 d blocks for analysis, the dates for which are:

Block 1	April 22-26
Block 2	April 27-May 1
Block 3	May 2-6
Block 4	May 7-11
Block 5	May 12-16
Block 6	May 17-21
Block 7	May 22-26
Block 8	May 27-31

The 45 d summer study was broken down into nine 5 d blocks as follows:

Block 9	July 1-5
Block 10	July 6-10
Block 11	July 11-15
Block 12	July 16-20
Block 13	July 21-25
Block 14	July 26-30
Block 15	July 31-August 4
Block 16	August 5-9
Block 17	August 10-14

The transducers used to monitor all locations had nominal beamwidths of approximately 15' at the -3 dB points (one way propagation). Two systems were used to monitor all locations. One system was dedicated to sampling the turbines, while the other sampled both the spill and sluice. Fast multiplexing enabled both the Spill and sluice to be sampled simultaneously. A total hourly sampling effort of 7.5 minutes per spill location and 15 minutes per sluice location was achieved in this way. The powerhouse was sampled with 8 minute intervals per hour at each turbine.

2.3 Summary of Dam operations

The spillway was operated for 10 hours each day from 0900 to 1900 h PST. Spill was initiated at The Dalles Dam on April 27, and continued daily throughout the spring study through June 1. Spill occurred in the summer study period from July 1 through July 10 (0900-1900 h). Thus daytime spill occurred throughout the spring blocks 2-8 and summer blocks 9 and 10.

The ice and trash sluiceway of Turbine Unit 1 was operated throughout the entire study period. The time periods of operations were as follows:

April 22 - May 6	0400 - 2000 hours (PST)
May 7 - 31	24 hour operation
July 1 - August 15	0400 - 2000 hours (PST)

Data acquisition procedures are described in Appendix B. Detailed descriptions of the various transducer mounting orientations are presented in Appendix C. Data analysis procedures are described in Appendix D.

3.0 FINDINGS

3.1 Objective 1: Effectiveness of Spill and Sluiceway for Passing Downstream Migrants

3.1.1 Introduction

spill has been found to be effective for safely passing downstream migrants at hydroelectric dams (Davidson 1965). Knowledge of the relationship between percent river spilled and percent migrant passage in spill is essential for making an informed evaluation of the efficiency of spill as a bypass mechanism.

The ice and trash sluiceway has also been shown to be a safe method for bypassing downstream migrants (Nichols 1979). Sluiceways are currently being used as fish bypasses at The Dalles, Bonneville and Ice Harbor dams. The results of previous tests done at The Dalles Dam suggest that the sluiceway is an effective bypass mechanism, but is highly dependent on specific sluiceway operating conditions (Nichols and Ransom 1980, 1981). At Ice Harbor Dam hydroacoustic tests found the ice and trash sluiceway to be very efficient as a bypass method (Johnson et al. 1982, 1984).

3.1.2 Methods

Spill effectiveness was evaluated from April27 to May 31, and from July 1 to July 10, 1985. spill occurred for 10 h from 0900-1900 h. There was no spill during the 14 h non-spill periods (1900-0900 h) for all 85 days. During the 35 days of spring spill, the instantaneous spill level (percent of river spilled) ranged from 13.1-29.6%. The 24 h daily average spill level ranged from 6.1-13.2%. During the 10 days of summer spill, the instantaneous spill levels ranged from 13.7-20.1%. The 24 h daily average spill level ranged from 7.3-11.1%.

Wide-beam transducers (15° nominal beam width) placed immediately in front of the operating spillways, sluiceways and turbine units were used to collect passage rate data. Each operating turbine unit, spill gate and sluice gate was sampled acoustically for approximately equal sample times each hour.

spill effectiveness was defined as the percentage of fish passed in spill relative to total estimated fish passage at The Dalles Dam. Individual data points were established two ways. The daytime spill blocks were evaluated to obtain data on 10 h "instantaneous" spill effectiveness (0900-1900 h). ("Instantaneous" in this report refers to a discrete spill level which was relatively constant for the 10 h spill period.) In addition, spill effectiveness was calculated on a 24 h daily average basis, with a passage day defined as the 24 h period from 0800-0800 h. Since there was zero spill during the 14 h non-spill periods, the 24 h daily averages do not represent 24 h of spill at a constant level, but rather the effect of 10 h of daytime spill on 24 h fish passage. The two series of data points (10 h and 24 h) were analyzed independently.

Sluiceway effectiveness was defined as the percentage of fish passed in sluice relative to the total estimated fish passing The Dalles Dam. From May 7 through May 31, 1985, the sluiceway operated for 24 hours per day. The sluiceway was operated 16 hours per day (0400-2000 h) April 22 through May 6 and July 1 through August 15, 1985. All sluiceway effectiveness estimates were calculated on a 24 h daily average basis.

There were 4 days during the spring season (April 27-30, 1985) when the sluiceway transducer mounts were damaged and needed to be repaired. During this period, no data were collected for the sluiceway.

3.1.3 Spring Results and Discussion

10 h Instantaneous and 24 h Daily Average Spill Effectiveness

Percent spill effectiveness on a 10 h instantaneous and 24 h daily average basis is presented by 5 d spill blocks in Table 1.

Figure 5 shows the relationship between percent river spilled and percent fish passed in spill for the days of Blocks 2-8. (Block 1 is absent since there was no spill during that time.) The instantaneous spill effectiveness ranged from 8.7 - 39.2%. The average instantaneous spill effectiveness for the entire spring season was 23.2%; the average spill was 21.8%.

The 24 h daily average spill effectiveness ranged from 3.1-18.9%. The mean 24 h daily average spill effectiveness for the entire spring study was 9.3%; the mean spill level was 10.1%.

The 10 h instantaneous and 24 h daily average spill effectiveness plotted individually with the best fit linear regression models are presented in Figures El and E2, Appendix **E.**

Comparison of Turbine, Spill, and sluiceway Effectiveness

The daily proportion of total fish passage through the powerhouse, spillway, and sluiceway for each day of the spring study is shown in Figure 6 and presented in Table 2, For each day, the sum of turbine, sluiceway, and spillway passage equals 100%.

The majority of fish passed through the turbine units (mean passage 67.6%) for Blocks 3-8 (periods of consistent sluiceway and spillway operation - May 1 to May 31). The mean spillway fish passage was 9.2%. The mean sluiceway passage was 23.2%, but since it used only 1.4 - 2.2% of the daily average river flow it was the most efficient method of passing fish on a percent flow basis. These results are very similar to those found at Ice Harbor Dam on the Snake River where Johnson et al. (1982, 1984) found that 24% fish passed through the sluiceway with only 1.5% of the river flow in 1982, and that 31% of the fish passed through the sluiceway with only 2.2% of the river flow in 1983.

percent sluice effectiveness on a 24 h daily average basis is presented by 5 d blocks for the spring study in Table El. The daily percent of total fish passage through the spill and sluice individually are presented in Figures E5 and E6, Appendix E.

Table 1. 10 h and 24 h spill effectiveness results for the spring study. The Dalles Dam, 1985.

		10 h				24 h			
	Date	Percent Fish		Percent River		percent Fish		Percent River	
Block 2	4/27	34.3		19.9		15.5		10.0	
	4/28	36.8		21.1		14.2		8.5	
	4/29	21.4		16.7		9.5		7.1	
	4/30	8.7		19.8		3.1		7.5	
(Average)	5/01	17.9	(23.8)	19.3	(19.4)	10.6	(10.6)	7.9	(8.2)
Block 3	5/02	11.2		16.3		5.6		7.7	
	5/03	37.2		14.6		18.9		6.8	
	5/04	33.6		20.6		11.7		8.6	
	5/05	39.2		18.6		15.6		7.4	
(Average)	5/06	16.1	(27.5)	13.1	(16.6)	6.0	(11.6)	6.1	(7.3)
Block 4	5/07	23.8		15.4		10.3		7.1	
	5/08	33.3		24.3		12.1		11.3	
	5/09	25.1		25.1		10.0		11.5	
	5/10	31.3		22.0		12.8		9.7	
(Average)	5/11	24.2	(27.5)	22.4	(21.9)	9.1	(10.9)	10.3	(10.0)
Block 5	5/12	23.7		29.6		8.4		11.3	
	5/13	32.4		23.2		14.1		9.7	
	5/14	21 .J		25.0		8.8		11.4	
	5/15	31.0		26.1		13.3		13.2	
(Average)	5/16	32.5	(28.2)	23.7	(25.5)	8.9	(10.7)	10.8	(11.3)
Block 6	5/1 7	24.2		27.1		8.6		12.4	
	5/18	18.3		25.0		7.7		11.6	
	5/19	20.1		25.7		7.4		11.2	
	5/20	29.5		23.2		11.8		10.8	
(Average)	5/21	13.1	(21.0)	22.9	(24.8)	5.6	(8.2)	11.1	(11.4)
Block 7	5/22	19.4		21.0		8.9		11.1	
	5/23	18.0		22.1		6.5		11 .J	
	5/24	12.5		20.6		4.6		10.7	
	5/25	14.4		25.0		4.2		11.6	
(Average)	5/26	11.9	(15.2)	21.7	(22.1)	4.5	(5.8)	11.6	(11.4)
Block 8	5/27	11.6		25.5		3.7		12.0	
	5/28	21.1		21.7		8.1		10.8	
	5/29	12.2		20.8		5.8		10.5	
	5/30	19.5		21.0		9.0		11.3	
(Average)	5/31	30.4	(18.9)	22.6	(22.3)	11.9	(7.7)	11.1	(11.1)
Season		23.2		21.8		9.3		10.1	

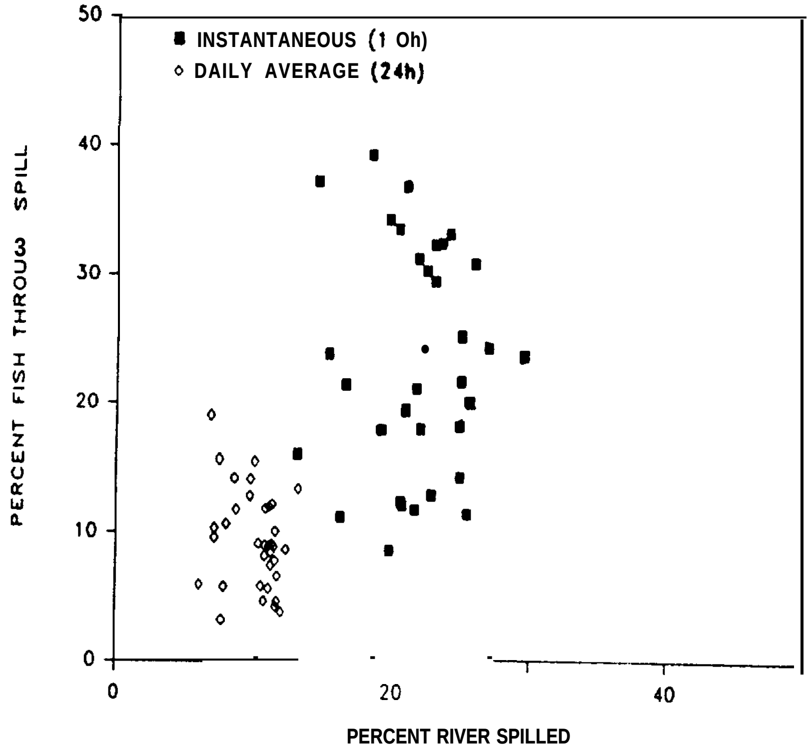

Figure 5. 10 h and 24 h spring spill effectiveness data points for Blocks 2-8. The Dalles Dam, 1985.

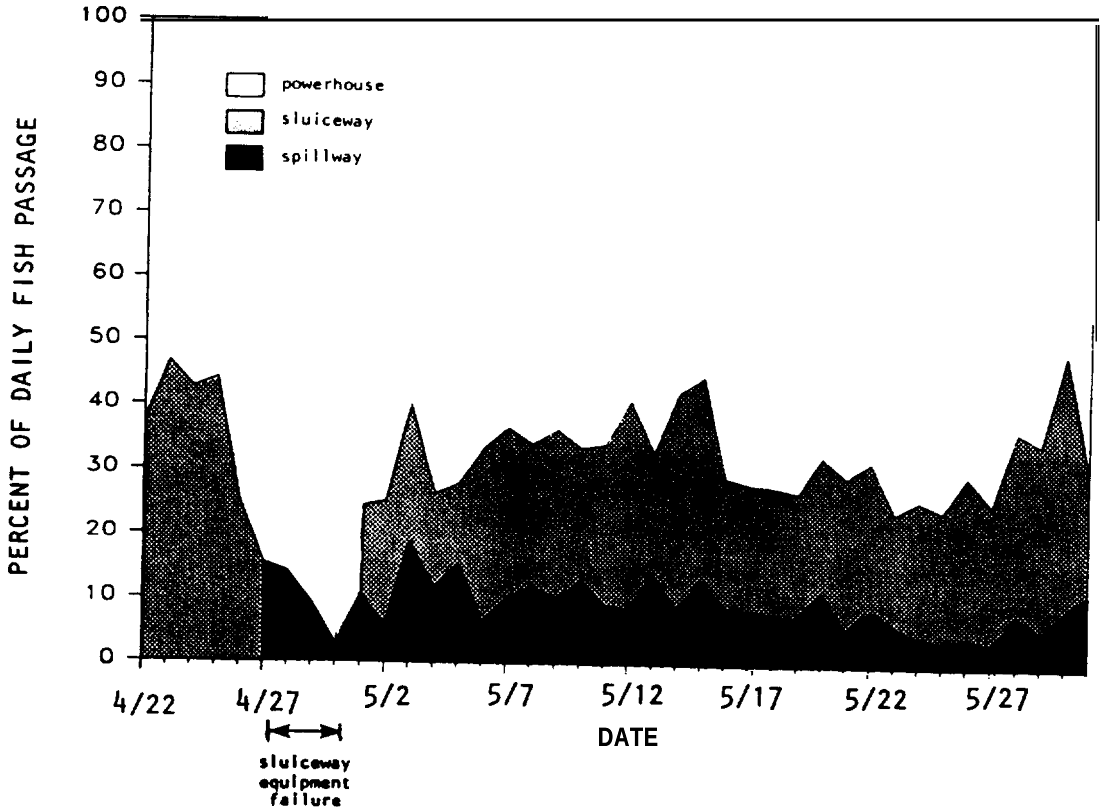

Figure 6. Comparison of the 24 h average turbine, spill, and sluice effectiveness during the spring study. The Dalles Dam, 1985.

Table 2. Daily average percent fish passage for each sample location during the spring study. The Dalles Dam, 1985.

Date	% Spill	% Sluice	% Turbine
4/22	NO SPILL	37.6	62.4
4/23	NO SPILL	46.9	53.1
4/24	NO SPILL	42.8	57.2
4/25	NO SPILL	44.3	55.7
4/26	NO SPILL	25.3	74.7
4/27	15.5	NO DATA	84.5
4/28	14.2	NO DATA	85.8
4/29	9.5	NO DATA	90.5
4/30	3.1	NO DATA	96.9
5/01	10.6	14.0	75.4
5/02	5.6	19.7	74.7
5/03	18.9	21.4	59.7
5/04	11.7	14.8	73.5
5/05	15.6	12.6	71.8
5/06	6.0	27.6	66.4
5/07	10.3	26.5	63.2
5/08	12.1	22.1	65.7
5/09	10.0	26.5	63.5
5/10	12.8	20.9	66.3
5/11	9.1	25.2	65.7
5/12	8.4	32.7	58.9
5/13	14.1	19.0	67.0
5/14	8.8	33.7	57.5
5/15	13.3	31.7	55.0
5/16	8.9	20.3	70.8
5/17	8.6	19.6	71.8
5/18	7.7	20.1	72.1
5/19	7.4	19.6	73.0
5/20	11.8	20.9	67.3
5/21	5.6	23.9	70.5
5/22	8.9	23.0	68.1
5/23	6.5	17.6	75.9
5/24	4.6	21.4	74.0
5/25	4.2	20.2	75.6
5/26	4.5	25.3	70.1
5/27	3.7	21.7	74.5
5/28	8.1	28.7	63.1
5/29	5.8	29.1	65.1
5/30	9.0	40.2	50.8
5/31	11.9	19.1	69.0
Season (5/1-5/31)	9.2	23.2	67.6

3.1.4 Summer Results and Discussion

10 h Instantaneous and 24 h Daily Average Spill Effectiveness

Summertime percent spill effectiveness on an instantaneous 10 h and 24 h daily average basis is presented in Table 3.

Figure 7 shows the relationship between percent river spilled and percent fish passed in spill for Blocks 9 and 10 (the 10 d period between July 1 and July 10 when water was passed through spill). The instantaneous spill effectiveness ranged from 28.7 - 59.2%. The average instantaneous spill effectiveness for the summer study was 39.9% with average spill of 17.8%. (Blocks 11-17 (July 11 to August 14) were not included in this analysis since there was no spill during this period.)

The 24 h daily average spill effectiveness ranged from 14.1 - 42.2% for the summer study (July l-20). The mean 24 h daily average spill effectiveness was 23.4%; the mean river spill was 9.8%.

The results indicate thatspillwas much more effective at passing fish during the summer than during the spring season. An average spill level of 17.8% resulted in a mean 10 h instantaneous spill effectiveness of 39.9% for summer while an average spill level of 21.8% resulted in a mean spill effectiveness of 23.2% for the spring study.

Many factors could have contributed to this difference between spring and summer. The summer season consisted primarily of subyearling chinook smolts, while the spring season consisted of chinook yearlings, steelhead and sockeye smolts (see Section 3.2 for species composition results). The magnitude of the spring run was greater than the magnitude of the summer run (see section 3.2 for the run timing results). Also, the river flow during the spring was as much as three times greater than the flow past the project during the summer (see Table F1 in Appendix F).

The 10 h instananeous and 24 h daily average spill effectiveness plotted individually with the best fit linear regression models are presented in Figures E3 and E4, Appendix E.

Comparison of Turbine, Spill, and Sluiceway Effectiveness

During the 10 d period from July 1 to July 10 when summer spill occurred, the mean proportionate fish passage for turbines, spill way, and sluiceway was 62.4%, 23.4% and 14.2%, respectively.

The daily proportion of total project fish passage through the powerhouse, spillway, and sluiceway for each day (24 h) of the summer study is shown in Figure 8 and presented. in Table 4. During the period from July 11 to August 14 (Blocks 11-17 when no spill occurred) fish passage through the turbines and sluiceway were at very similar proportions. The mean percent passage for the turbines and sluiceway for this period was 51.3% and 48.7%, respectively. Water flow into the sluiceway ranged from only 2-5% of the daily average river flow.

Percent sluice effectiveness on a 24 h daily average basis is presented by 5 d blocks for the summer study in Table E2. The daily percent of total fish passage through the spill and sluice individually are presented in Figures E7 and E8, Appendix E.

Table 3. 10 h and 24 h spill effectiveness results for the summer study. The Dalles Dam, 1985.

	Date	10 h Percent Fish		10 h Percent River		24 h Percent Fish		24 h Percent River	
Block 9	7/01	59.2		17.0		42.2		9.2	
	7/02	41.7		20.1		26.3		10.8	
	7/03	37.7		17.9		24.7		10.1	
	7/04	38.0		17.3		23.7		9.9	
(Average)	7/05	36.5	(42.6)	18.0	(18.1)	21.7	(27.8)	10.1	(10.0)
Block 10	7/06	28.7		18.3		14.1		9.8	
	7/07	34.9		13.7		18.3		7.3	
	7/08	45.9		19.6		22.3		11.1	
	7/09	43.9		19.5		23.4		10.2	
(Average)	7/10	32.2	(37.1)	16.2	(17.5)	16.6	(18.9)	8.8	(9.5)
Season		39.9		17.8		23.3		9.7	

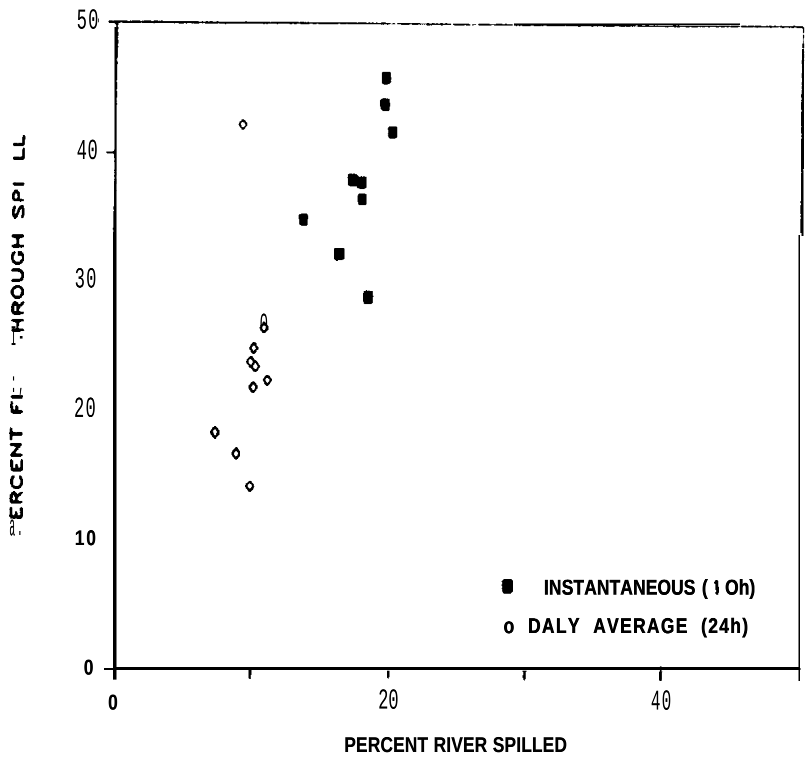

Figure 7. 10 h and 24 h summer spill effectiveness data points for Blocks 9 and 10. The Dalles Dam, 1985.

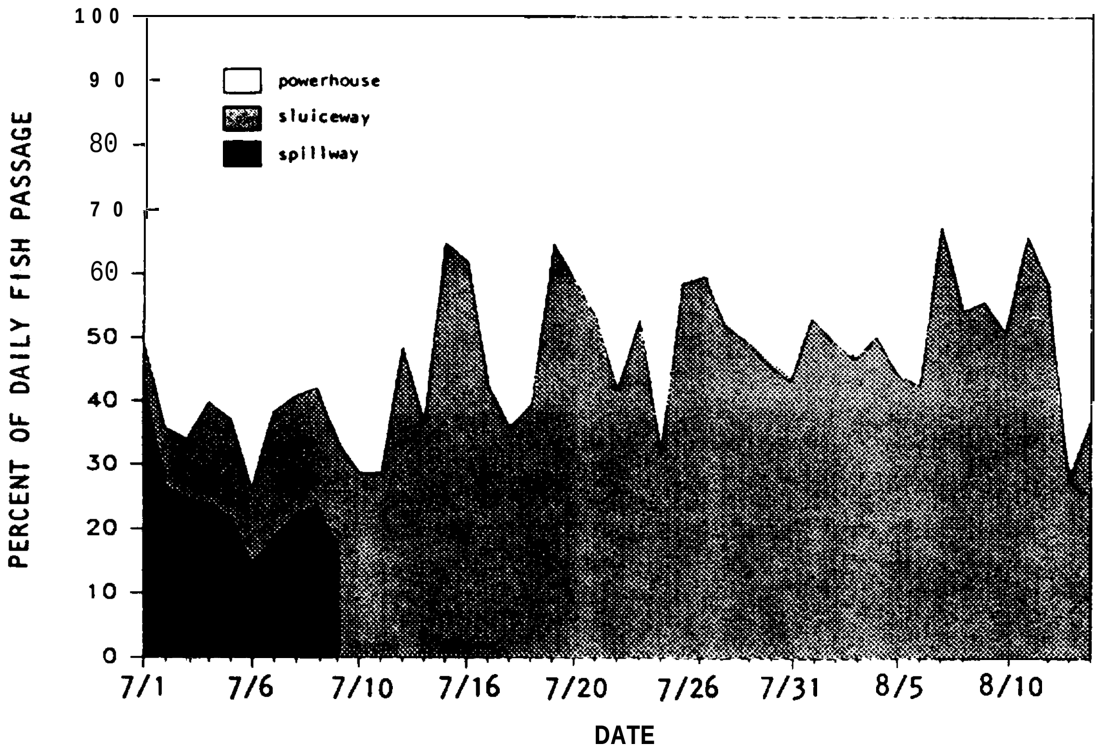

Figure 8. Comparison of the 24 h average turbine, spill, and sluice effectiveness during the summer study. The Dalles Dam, 1985.

Table 4. Daily average percent fish passage for each sample location during the summer study. The Dalles Dam, 1985.

Date	% spill	% Sluice	% Turbine
7/01	42.2	7.0	50.8
7/02	26.3	9.2	64.5
7/03	24.7	9.1	66.2
7/04	23.7	16.0	60.3
7/05	21.7	15.4	62.9
7/06	14.1	11.7	74.2
7/07	18.3	20.1	61.6
7/08	22.3	18.5	59.2
7/09	23.4	18.6	58.0
7/10	16.6	16.8	66.6
7/11	No Spill	28.6	71.4
7/12	"	28.7	71.3
7/13	"	48.5	51.5
7/14	"	36.4	63.6
7/15	"	64.7	35.3
7/16	"	61.9	38.1
7/17	"	42.3	57.7
7/18	"	35.9	64.1
7/19	"	39.6	60.4
7/20	"	64.8	35.2
7/21	"	59.0	41.0
7/22	"	53.3	46.7
7/23	"	41.7	58.3
7/24	"	52.9	47.1
7/25	"	32.1	67.9
7/26	"	58.5	41.5
7/27	"	59.5	40.5
7/28	"	51.8	48.2
7/29	"	49.5	50.5
7/30	"	45.9	54.1
7/31	"	43.0	57.0
8/01	"	53.1	46.9
8/02	"	49.6	50.4
8/03	"	46.8	53.2
8/04	"	50.3	49.7
8/05	"	44.2	55.8
8/06	"	42.7	57.3
8/07	"	67.5	32.5
8/08	"	54.3	45.7
8/09	"	55.7	44.3
8/10	"	50.8	49.2
8/11	"	66.0	34.0
8/12	"	58.6	41.4
8/13	"	27.3	72.7
8/14	"	37.4	62.6
Season (7/11-8/14)		48.7	51.3

3.2 Objective 2: Run Timina of Downstream Miarants

3.2.1. Introduction

The seasonal timing of migrant passage through this and other dams defines the periods of time when bypass methods may be most effectively used. Knowledge of the annual pattern of migrant passage at several points on the Columbia River may enhance the efficiency of bypass methods.

3.2.2. Methods

Daily project fish passage estimates were expressed as percentages of the total number of fish estimated to have passed the project during the 40 d spring study (April 22-May 31) and the 45 d summer study (July l-August 14). The spring and summer data were also combined to show the daily run magnitude for all 85 days.

It should be emphasized that the cumulative run timing estimates for the spring and sumer migrations apply only to the respective 40 d and 45 d study periods. Thus, these estimates do not reflect the numbers of migrants that may have passed the dam before, in-between, or after the study periods.

"In-season" passage indices (in relative fish/min) were also computed daily in the field and provided to the BPA and water Budget Center to aid in the management decisions. These data are also presented in this report. **Note** that the in-season index is in units of relative fish/min whereas the daily and cumulative run timing are expressed as percentages of the total runs. By coincidence, these numbers **were** of similar magnitude, as shown by the respective scales on Figures 9 and 12.

Species composition data is provided from John Day Dam, 24 miles upstream of The Dalles. This data, which was obtained from the gatewell smolt index provided by the Water Budget Center's Weekly Reports, does not represent the exact species composition at The Dalles Dam. However, with a small delay period (perhaps 24-48 hours), the trends in species composition should be similar at The Dalles Dam.

3.2.3. Spring Results and Discussion

Daily and cumulative run timings during the spring study are presented in Figures 9 and 10, respectively, as well as Table 5. The "in-season" indices of run timing are also presented in Figure 9 and Table 5. A comparison of the "in-season" indices and the expanded total passage estimates showed that they were quite similar, thus indicating that the index was reliable for estimating run timing.

The comparison of the percent run timing results with the "in-season" index is presented in Figure F1, Appendix F.

From the beginning of the spring period (April 22), the run magnitude increased at a relatively steady rate to the highest run timing peak (total passage estimate) which was observed on May 16. Another smaller peak in passage occurred on May 20. Thereafter, passage gradually decreased through the end of the spring study.

The cumulative run timing shows that the majority of the run passed toward the end of the spring study period (Figure 10). By May 16 (63% into the study period when the peak of the run occurred) 50% of the detected fish had passed The Dalles Dam.

Since several species are included in the spring migrations on the Columbia River, run timing estimates during this time of year may be influenced by the changing species compositions. These data are presented in Figure 11. (Note: since the species compositions in Figure 11 are expressed in daily percentages, it would not be valid to derive species-specific run timings from this figure.)

The spring species composition from the John Day Dam smolt index is presented in Table F1. The total project river flow during the spring study is presented in Table F3 and in Figure F3, Appendix F.

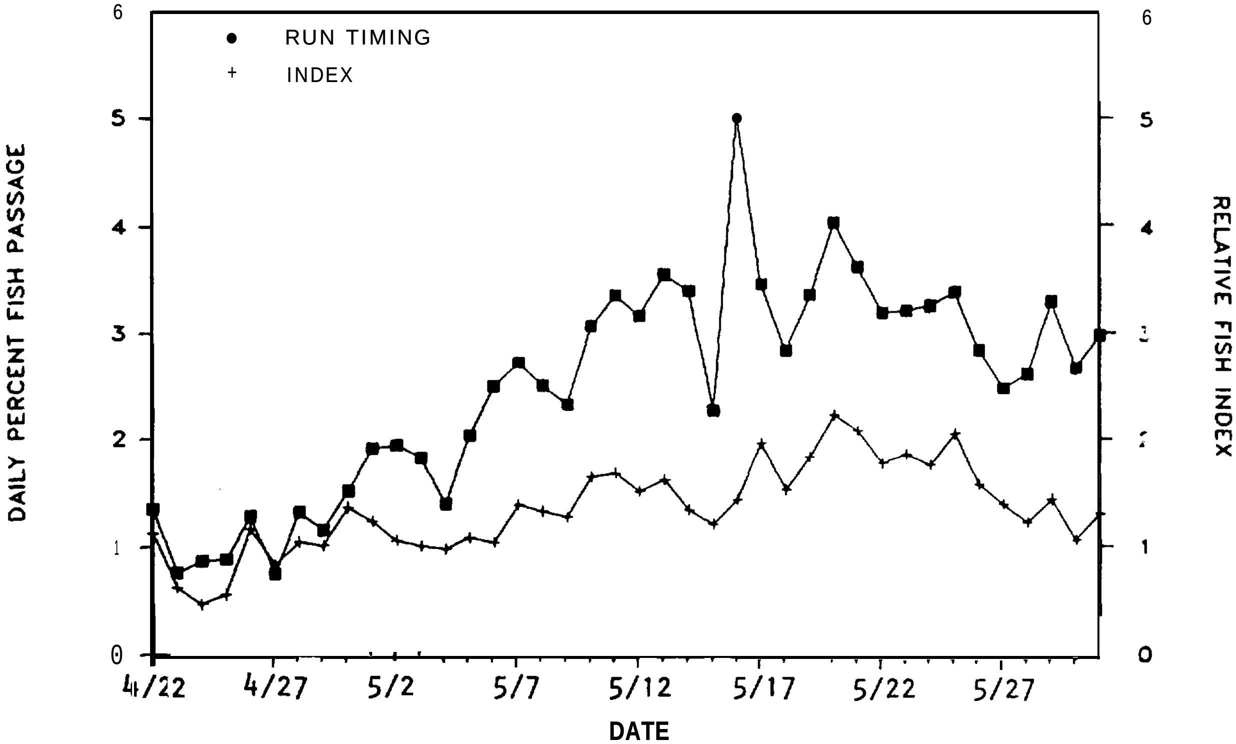

Figure 9. Daily percentage of fish passage and the relative "in-season" fish index during the 40 d spring study period. The Dalles Dam, 1985.

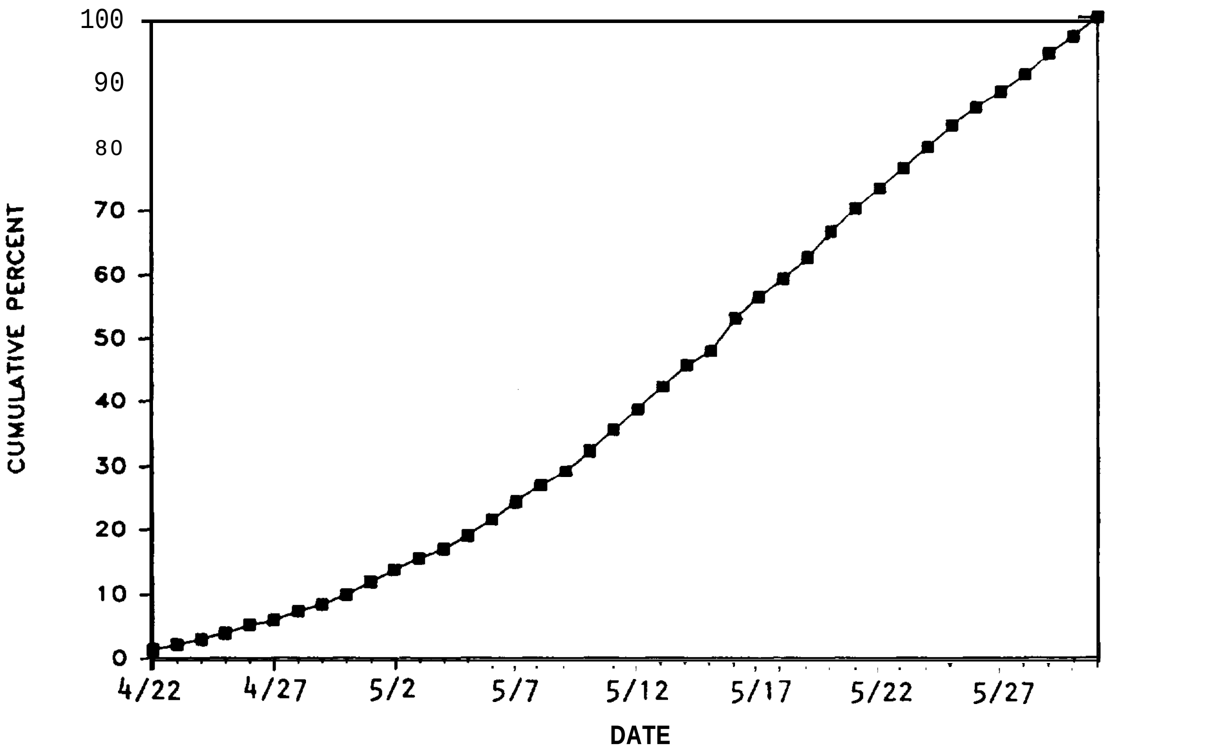

Figure 10. Cumulative percentage of fish passage during the 40 d spring study. The 0% and 100% points represent the beginnning and end of the spring sampling period and not necessarily the beginning and end of the migration. The Dalles Dam, 1985.

Table 5. Daily and cumulative run timing results and the "in-season" indices for the spring study. The Dalles Dam, 1985.

DATE	In-Season Fish/Minute Index	Total Project Daily % Fish	Total Project Cumulative % Fish
4/22	1.12	1.35	1.35
4/23	0.62	0.76	2.11
4/24	0.47	0.86	2.97
4/25	0.55	0.88	3.86
4/26	1.17	1.29	5.15
4/27	0.84	0.75	5.90
4/28	1.05	1.33	7.23
4/29	1.01	1.16	8.39
4/30	1.37	1.52	9.91
5/01	1.25	1.92	11.83
5/02	1.06	1.95	13.78
5/03	1.01	1.83	15.61
5/04	0.98	1.40	17.01
5/05	1.09	2.04	19.05
5/06	1.05	2.50	21.55
5/07	1.39	2.72	24.27
5/08	1.34	2.50	26.77
5/09	1.28	2.33	29.10
5/10	1.65	3.06	32.17
5/11	1.69	3.35	35.52
5/12	1.51	3.16	38.67
5/13	1.63	3.55	42.22
5/14	1.35	3.40	45.61
5/15	1.21	2.27	47.88
5/16	1.44	5.03	52.92
5/17	1.97	3.45	56.37
5/18	1.53	2.83	59.20
5/19	1.83	3.35	62.54
5/20	2.22	4.02	66.57
5/21	2.08	3.61	70.17
5/22	1.78	3.18	73.36
5/23	1.85	3.20	76.56
5/24	1.76	3.25	79.81
5/25	2.05	3.37	83.18
5/26	1.57	2.83	86.01
5/27	1.39	2.47	88.48
5/28	1.22	2.60	91.08
5/29	1.44	3.28	94.37
5/30	1.06	2.66	97.03
5/31	1.31	2.97	100.00

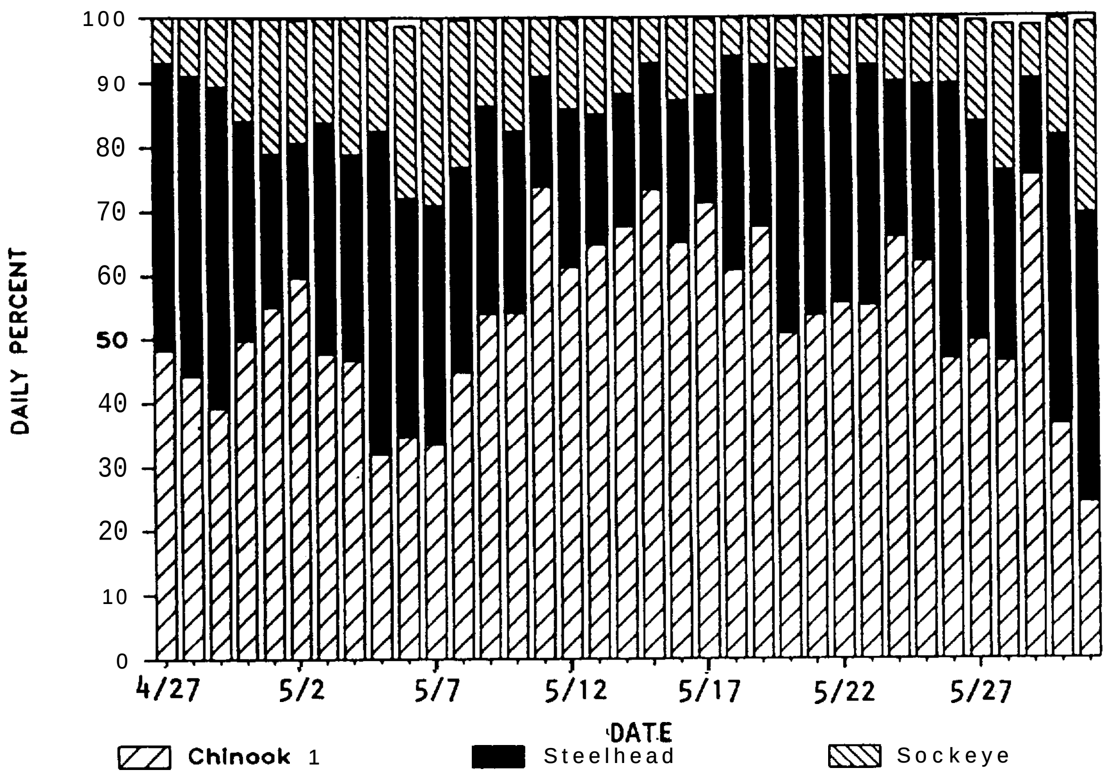

Figure 11. Daily percent species composition from the John Day Dam **smolt** index, 1985. Species composition is expressed in daily percentages and it would not be valid to derive **species-** specific run timings from this figure.

3.2.4 Summer Results and Discussion

Daily and cumulative run timing during the summer study are presented in Figures 12 and 13, as well as Table 6. The summer "in-season" indices are also presented in Figure 12 and Table 6. The highest run timing peak (total passage estimate) was observed on July 3. Except for minor peaks, the passage gradually decreased throughout the summer season.

The comparison of the percent run timing results with the "in-season" index is presented in Figure F2, Appendix F.

Cumulative run timing shows the majority of the fish passed early in the summer study (Figure 13). By July 14 (31% into the study period) 50% of the detected fish had passed The Dalles Dam.

According to data collected at John Day Dam, the species composition throughout the summer season was almost entirely sub-yearling chinook.

The summer species composition from the John Day Dam smolt index is presented in Table F2. The total project river flow during the summer study is presented in Table F4 and in Figure F4, Appendix F.

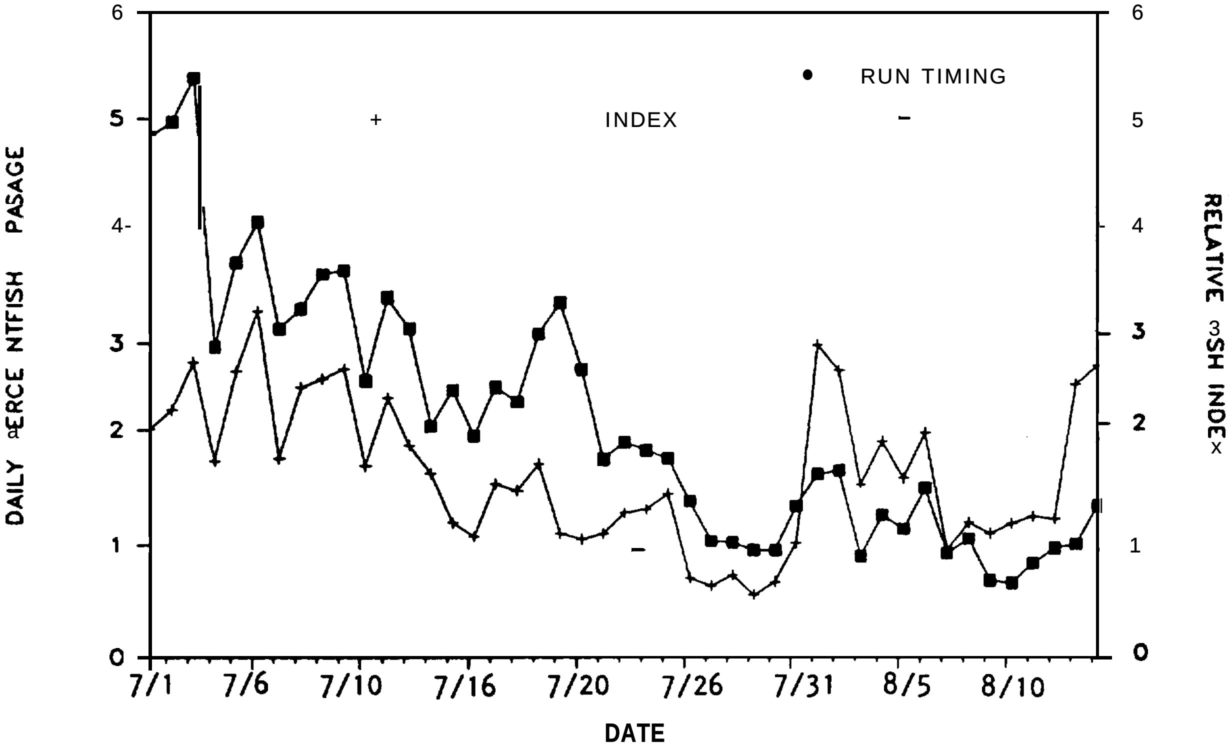

Figure 12. Daily percentages of fish passage and the relative "in-season" index during the 45 d summer study period. The Dalles Dam, 1985.

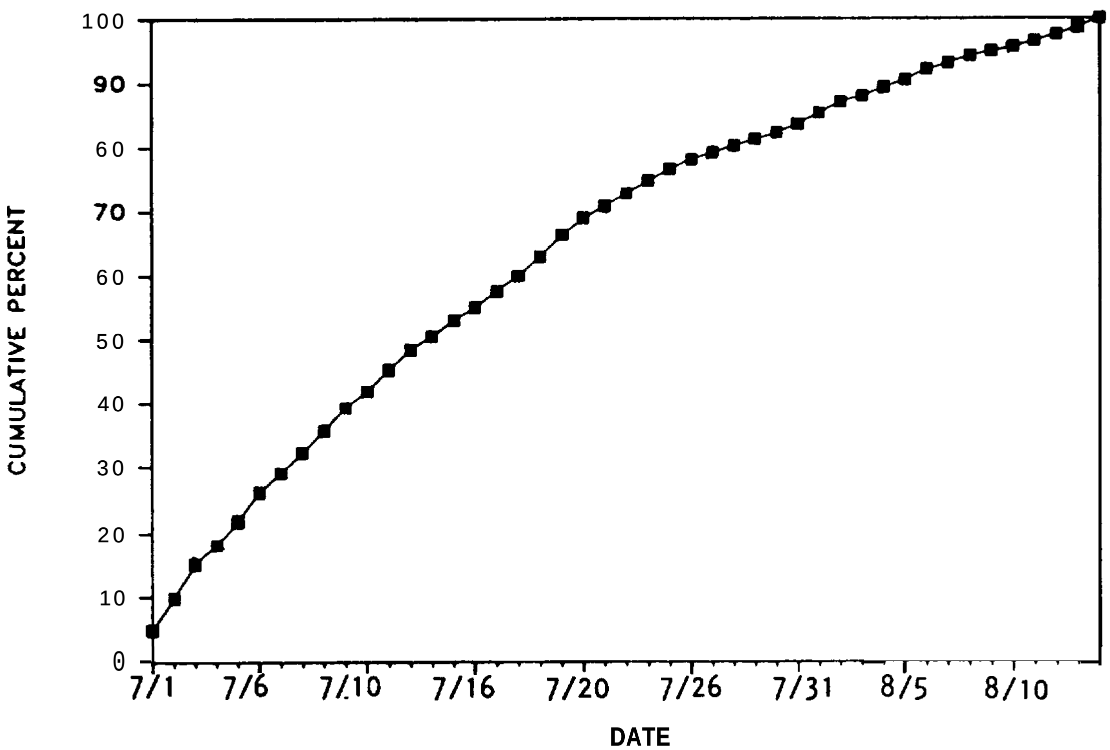

Figure 13. Cumulative **percentage** of fish passage during the 45 d summer study. The 0% and 100% points represent the beginning and end of the summer sampling period and not necessarily the beginning and end of the migration. The Dalles Dam, 1985.

Table 6. Daily and cumulative run timing results and the "in-season" indices for the summer study. The Dalles Dam, 1985.

DATE	In-Season Fish/Minute Index	Total Project Daily % Fish	Total Project Cumulative % Fish
7/01	2.13	4.85	4.85
7/02	2.31	5.00	9.85
7/03	2.76	5.40	15.25
7/04	1.84	2.89	18.15
7/05	2.67	3.68	21.82
7/06	3.23	4.06	25.88
7/07	1.86	3.06	28.94
7/08	2.52	3.25	32.19
7/09	2.60	3.57	35.76
7/10	2.69	3.60	39.36
7/11	1.79	2.58	41.94
7/12	2.42	3.35	45.29
7/13	1.98	3.06	48.35
7/14	1.72	2.16	50.51
7/15	1.26	2.49	53.00
7/16	1.13	2.07	55.06
7/17	1.62	2.52	57.58
7/18	1.56	2.39	59.97
7/19	1.81	3.01	62.98
7/20	1.16	3.31	66.29
7/21	1.11	2.68	68.97
7/22	1.16	1.85	70.82
7/23	1.35	2.01	72.83
7/24	1.39	1.93	74.77
7/25	1.53	1.86	76.63
7/26	0.74	1.46	78.09
7/27	0.67	1.08	79.17
7/28	0.77	1.07	80.24
7/29	0.58	1.00	81.24
7/30	0.70	1.00	82.24
7/31	1.06	1.41	83.65
8/01	2.90	1.71	85.37
8/02	2.67	1.75	87.11
8/03	1.62	0.94	88.05
8/04	2.01	1.33	89.39
8/05	1.67	1.20	90.58
8/06	2.09	1.58	92.17
8/07	0.99	0.97	93.13
8/08	1.26	1.10	94.24
8/09	1.15	0.71	94.95
8/10	1.25	0.69	95.64
8/11	1.31	0.87	96.52
8/12	1.29	1.01	97.53
8/13	2.54	1.05	98.59
8/14	2.72	1.41	100.00

3.2.5 Comparison of Spring and Summer Run Timing

Daily run timing for the combined spring and summer studies is presented in Figure 14. The height of each bar on the histogram represents, for each day, the percentage of the combined spring and summer migrations (i.e. total for spring plus summer equals 100%). The beginning of the spring and the end of the summer study showed similar magnitudes of fish passage. However, most of the downstream fish migration occurred during the second half of the spring study.

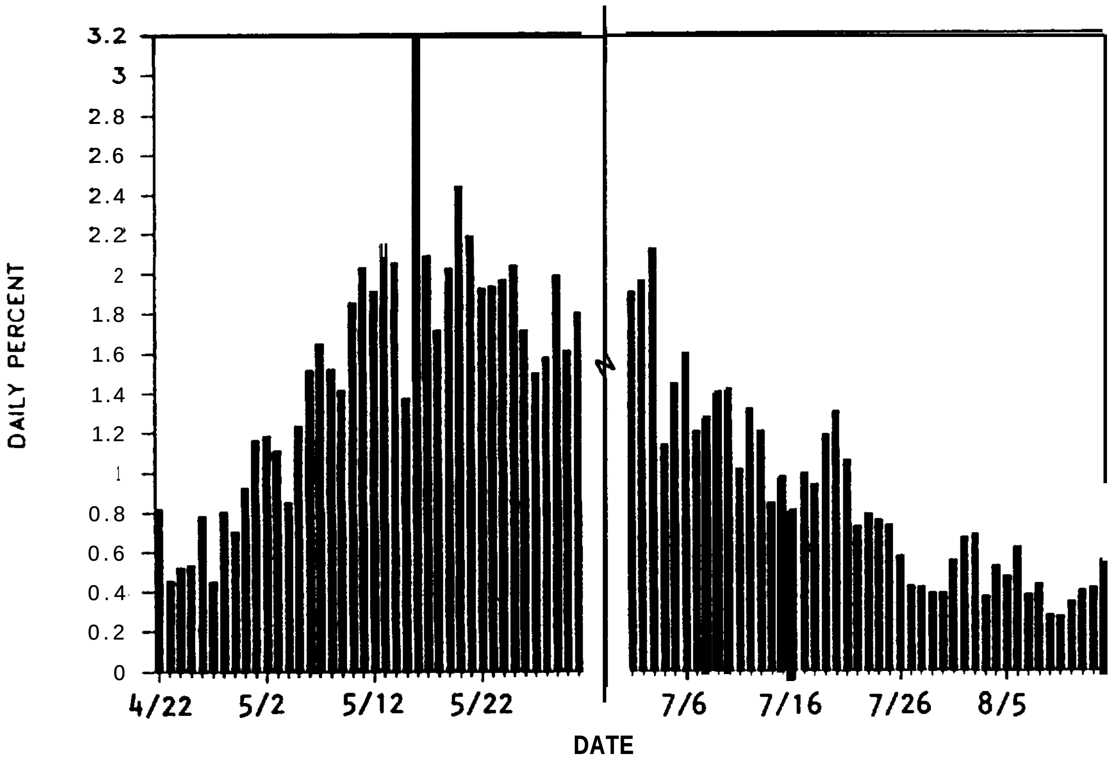

Figure 14. Daily percentages of fish passage for the 40 day spring and the 45 day summer studies combined. The Dalles Dam, 1985.

3.3 Objective 3: Diel Passage Rates of Downstream Migrants

3.3.1 Introduction

Diel estimates of fish passage show peaks in migrant passage throughout the day. This information aids in the efficient implementation of migrant bypass measures to maximize the use of bypass facilities during peak passage hours.

3.3.2 Methods

The data used for diel distributions were those obtained with the 15° transducers in front of the spillway, sluiceway and powerhouse. Diel distributions of fish migrating downriver were calculated using hourly time blocks which were grouped in three different ways:

1) The hourly diel passage was combined for all locations together and was averaged for three different parts of the season. The grouped time periods were Blocks 4-8 (spring study - with daytime spill - May 7 to May 31), Blocks 9 and 10 (summer study - with daytime spill - July 1 to July 10) and Blocks 11-17 (summer study - with no spill - July 11 to August 14);

2) The hourly diel passages by individual location (turbine, spillway and sluiceway) were grouped into the same season blocks as described above. The hourly distributions of river flow through The Dalles Dam were grouped the same as the composite diel distributions;

3) Finally, the hourly data was combined into 14 h and 10 h time blocks corresponding to daytime (0600-2000 h) and nighttime (2000-0600 h). These time blocks correspond roughly to hours of daylight and darkness. This was done for each day of the spring and summer studies.

For more information on methods used to calculate diel periodicity, see Appendix D.

3.3.3 Spring Results and Discussion

Average hourly passage for turbines, spillway, and sluiceway combined for Blocks 4-8 (May 7 to May 31) is shown in Figure 15. The distribution is bimodal, with the largest peak.during the evening hours (centered at 2000 h) and a smaller peak in the late morning (1000 h). The morning peak follows the beginning of daytime spill.

The average hourly percent flow for Blocks 4-8 is shown in Figure 16. The flow distribution shows similar trends, but not as pronounced as the fish passage distribution for the same time block. The largest flow peak was in the morning (0900 h).

The diel distributions at each location (turbines, spill and sluice) provide a more detailed view of juvenile fish movement. The composite diel distribution for Blocks 4-8 (May 7 to May 31) for each location is shown in Figure 17. Fish passage through the turbine units showed a rapid increase from 1900 h to 2000 h following the termination of spill. This also corresponded to the period of dusk. The sluiceway fish passage peaked at 0400 h following a drastic drop in fish passage at the powerhouse. This characteristic of fish movement, given the proximity of the sluiceway to the turbine intakes, was very likely caused by both the increase of fish activity at dawn and the dramatic shift in migrant vertical distribution (see section 3.5).

Fish passage through spill was relatively constant throughout the 10 h period during which spill occurred.

The average hourly fish passage for all the locations combined for each block of the spring study are presented in Table G1. Figures G1-G24 in Appendix G show the hourly diel distributions (combined and by location) and hourly flow distributions for all blocks during the spring study.

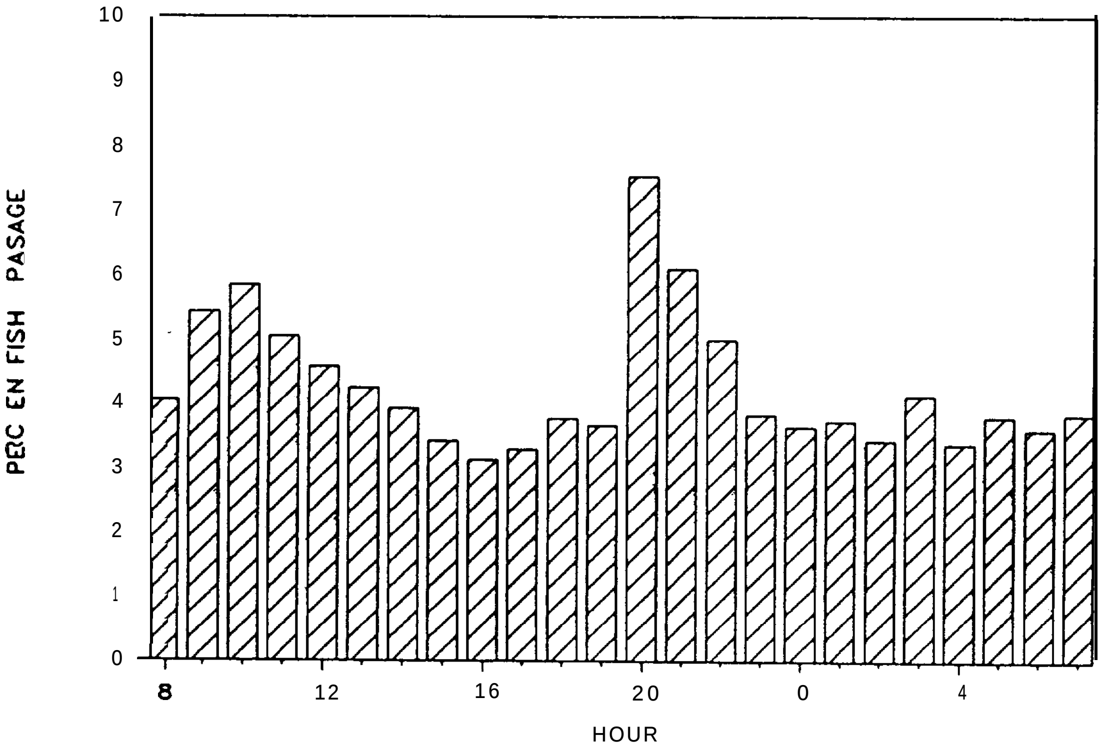

Figure 15. Hourly composite of the distribution of fish passage for Blocks 4-8. The Dalles Dam, 1985.

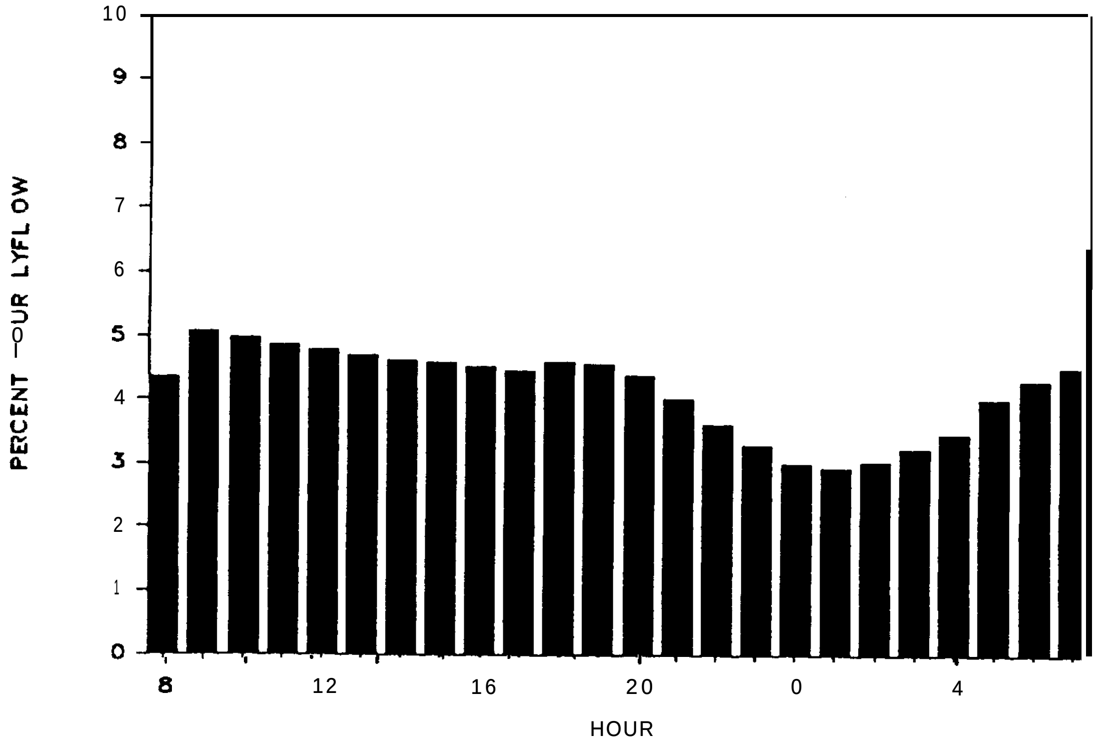

Figure 16. Hourly composite of the distribution of river flow for Blocks 4-8. The Dalles Dam, 1985.

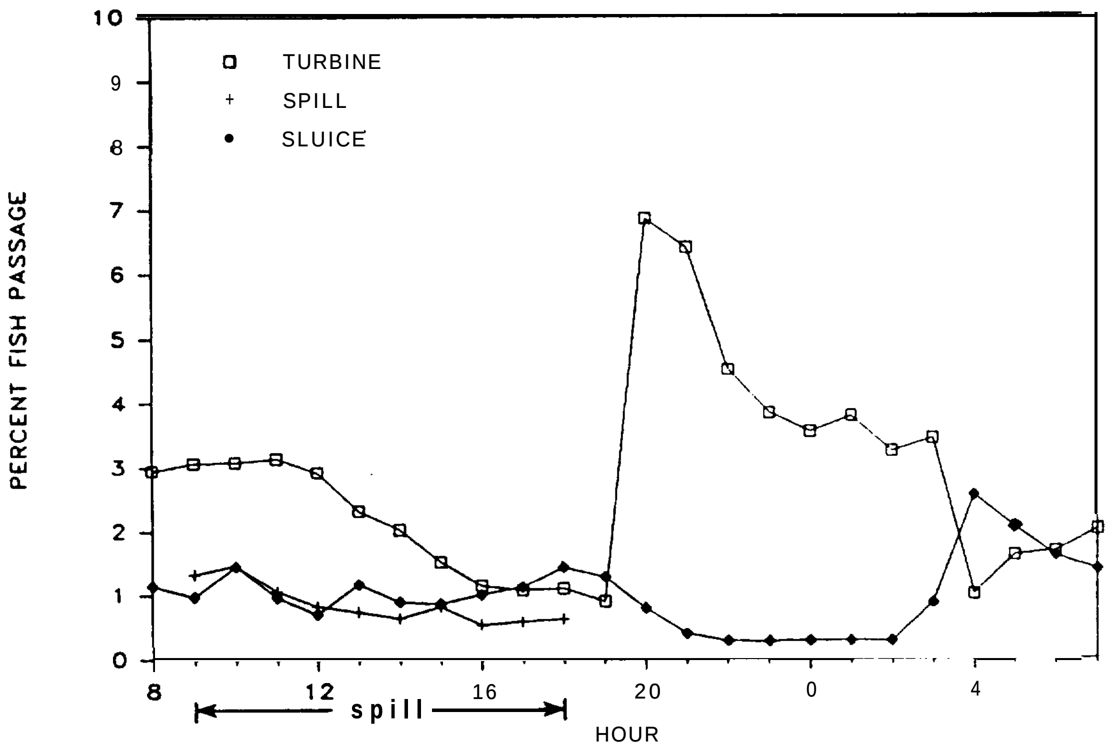

Figure 17. Individual turbine, spillway, and sluiceway hourly distribution of fish passage for Blocks 4-8. The Dalles Dam, 1985.

3.3.4 Summer Results and Discussion

The composite diel distribution and the average hourly flow distributions are presented in Figures 18 and 19 respectively for Blocks 9 and 10 combined (July 1 to July 10 when spill occurred). There was high daytime fish passage with moderate peaks at 1500 h and 1700 h. The hourly flow distribution was very similar to the hourly fish passage distibution. The average peak flow during these blocks occurred in the middle of the day.

The diel distributions at each location (turbines, spill and sluice) for blocks 9 and 10 is shown in Figure 20. Relative fish passage between the turbine units, spill, and sluice was quite different for the summer study than for the spring study period. Relative passage though the spill is higher in summer than in spring. Sluiceway passage appears less variable and turbine passage, for the summer, exhibits a much smaller relative evening peak (after termination of spill and sluice flow). As suggested before, this could be the result of many factors, including species composition, water temperature, dam operations and river flow rates.

The composite diel distribution for Blocks 11-17 (the period with no summer spill - July 11 to August 14) is shown in Figure 21. Figure 22 shows the average hourly flow distribution. There was a large peak in fish passge at 1900 h; however, the hourly river flows were relatively constant with a slight nighttime decrease.

Figure 23 shows the average individual diel distributions for the turbines and sluiceway during Blocks 11-17. The sluiceway passage was relatively constant until 1900 h when a large peak occurred. The powerhouse fish passage was also relatively constant with an evening increase from 2000-2200 h (corresponding to the termination of sluiceway flow).

The average hourly fish passage for all the locations combined for each block of the summer study are presented in Table G2. Appendix G includes figures of hourly diel distributions (combined and by location) and hourly flow distributions for all blocks during the summer study and are presented in Figures G25-G51.

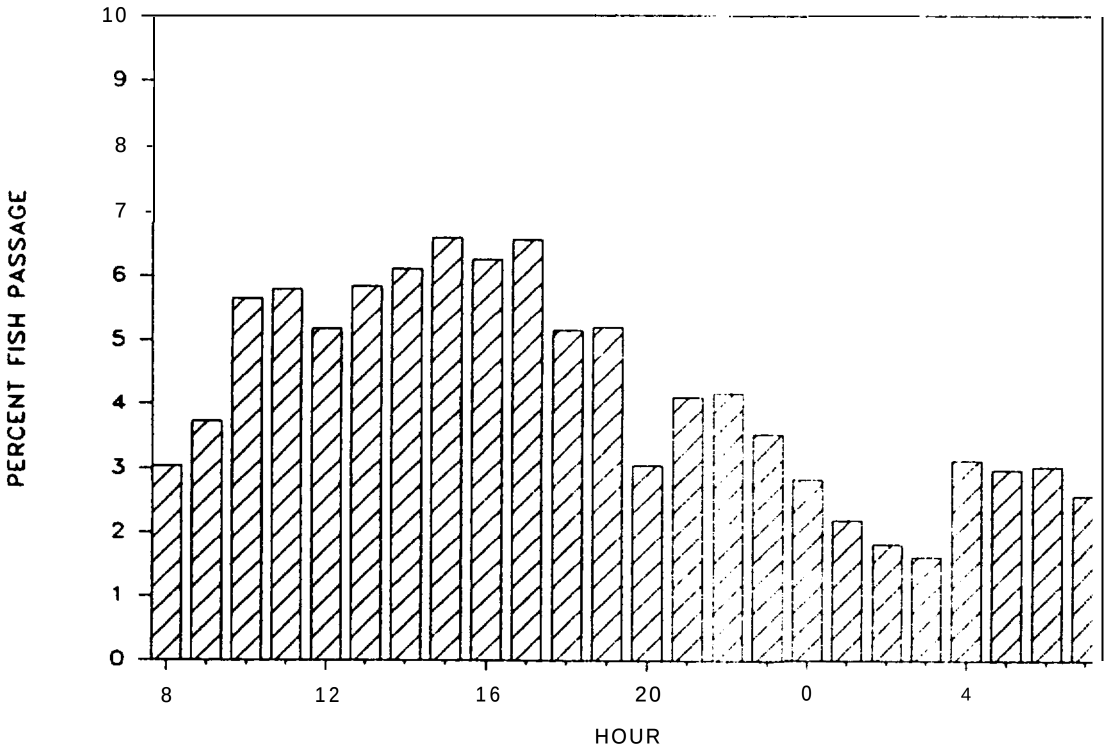

Figure 18. Hourly composite of the distribution of fish passage for Blocks 9 and 10. The Dalles **Dam,** 1985.

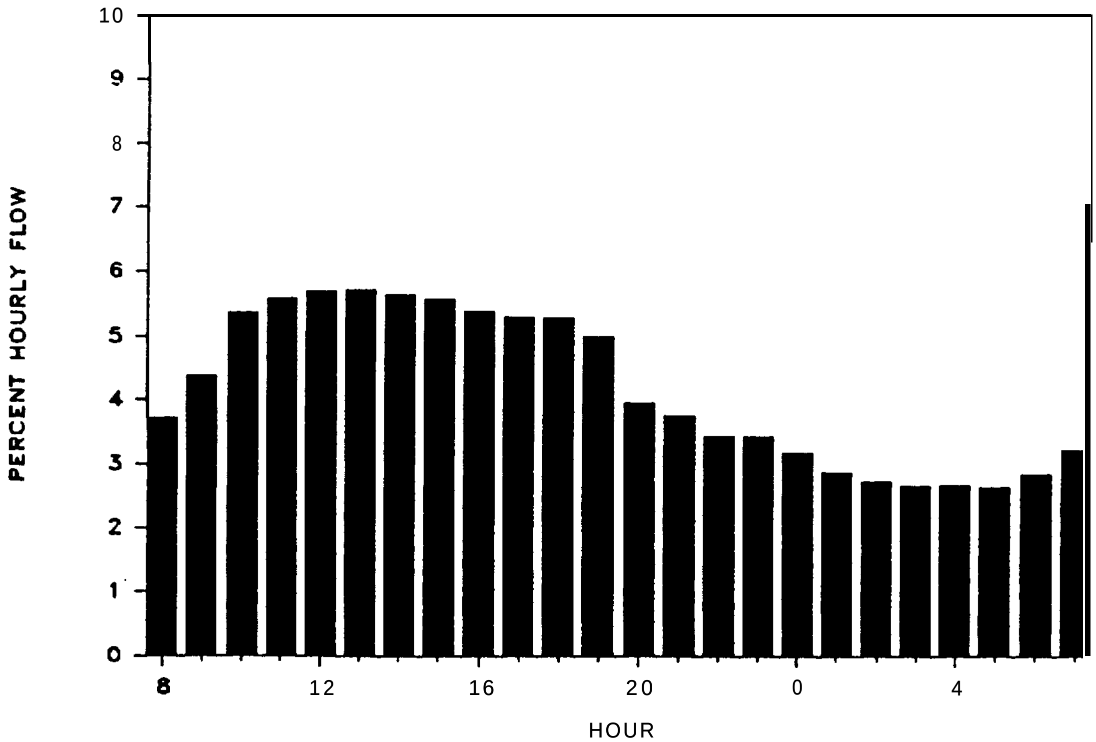

Figure 19. Hourly composite of the distribution of river flow for Blocks 9 and 10. The **Dalles** Dam, 1985.

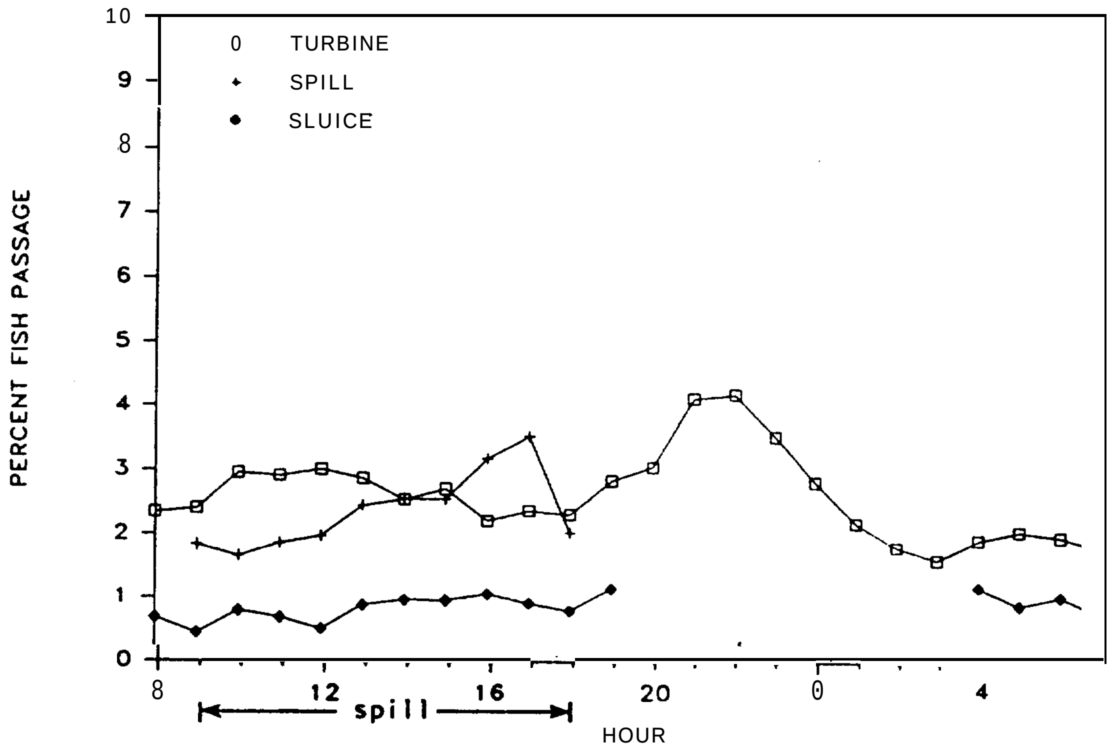

Figure 20. Individual turbine, spillway, and sluiceway hourly distribution of fish passage for Blocks 9 and 10. The Dalles Dam, 1985.

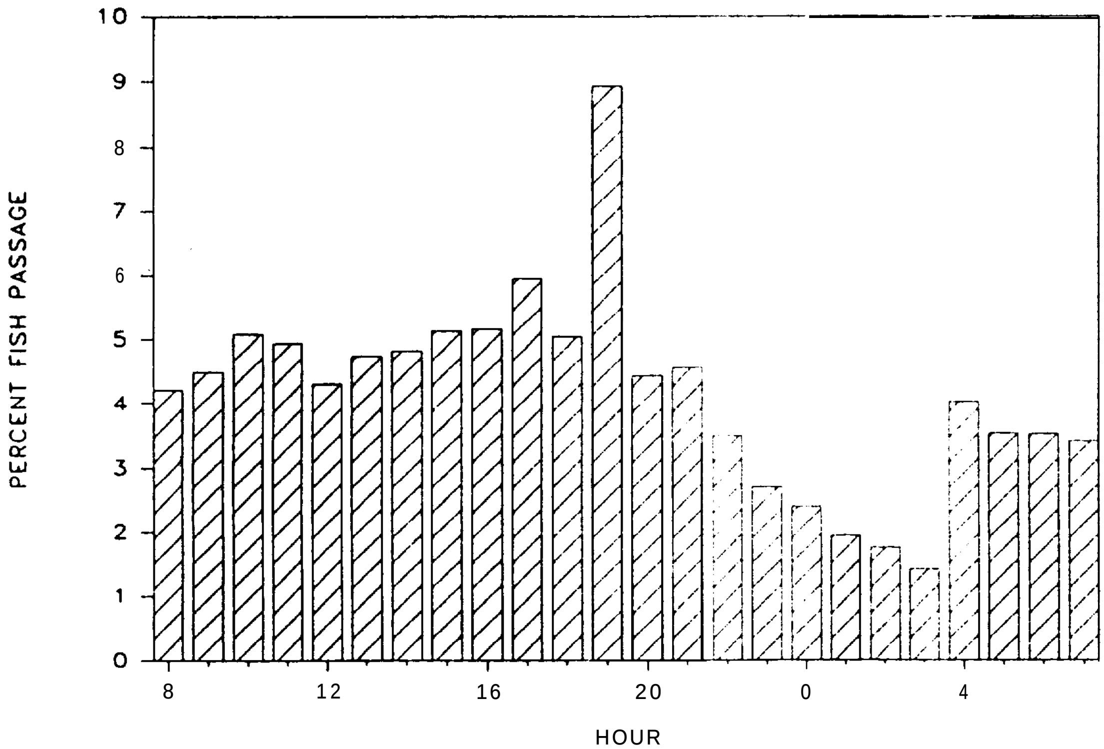

Figure 21. Hourly composite of **the** distribution of fish passage for Blocks 11-17. The Dalles Dam, 1985.

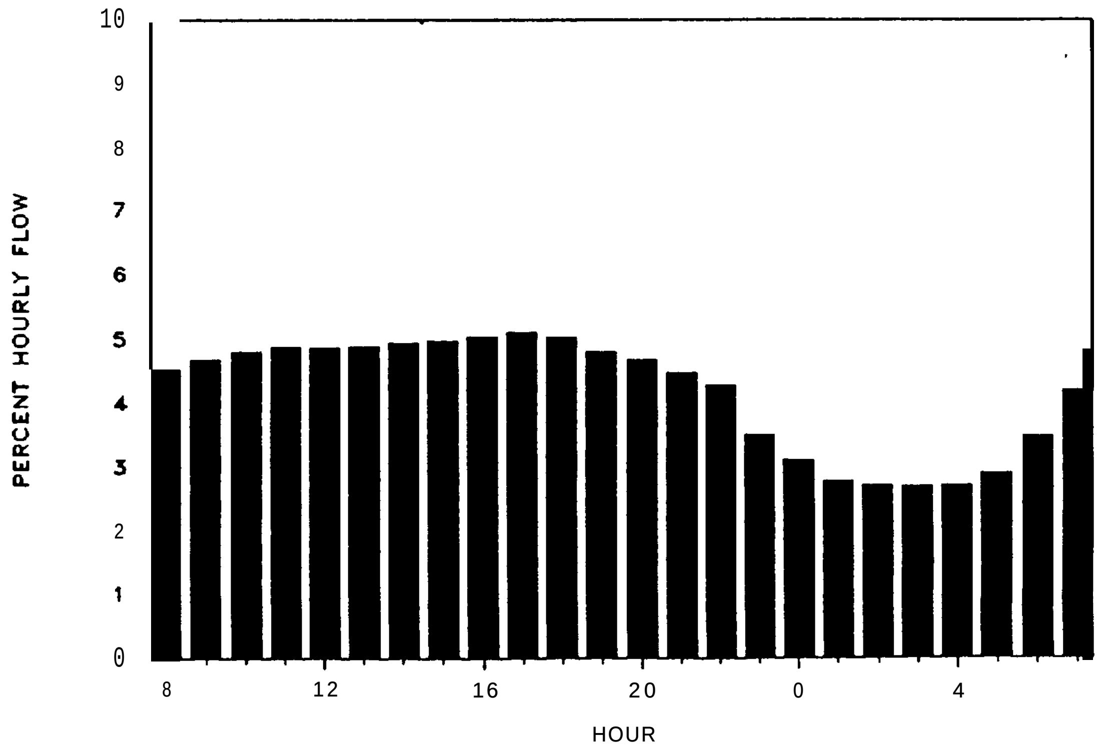

Figure 22. Hourly composite of the distribution of river flow for Blocks 11-17. The Dalles Dam, 1985.

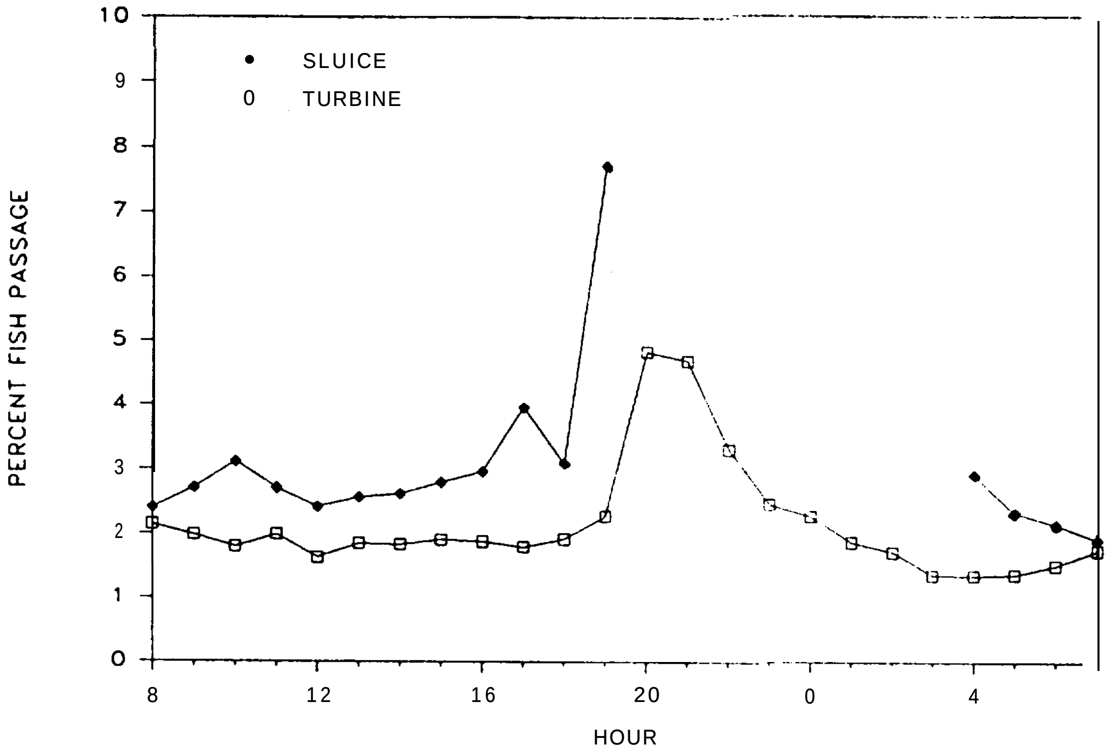

Figure 23. Individual turbine and sluiceway hourly distribution of fish passage for Blocks 11-17. The Dalles Dam, 1985.

3.3.5 Comparison of Spring and Summer Diel Fish Passage

The 14 h daytime (0600-2000 h) and 10 h nighttime (2000-0600 h) diel distributions for each day of the spring and summer studies are presented in Figures 24 and 25, respectively. The results are also presented in Table 7.

During the 40 d spring study, an average of 56.0% of the fish passed during the daytime (i.e., 58% of the 24 h) and 44.0% passed during the nighttime (42% of the 24 h). In contrast, during the 45 d summer study, an average of 69.6% of the fish passed during the daytime and 30.4% passed during the nighttime. Again, this could have resulted from many factors including species composition, run timing, river flow, water temperature and spillway and sluiceway operations.

The daytime/nighttime results showed that during the summer study the fish passed the project primarily during the daylight hours in contrast to the spring study when the fish passed constantly throughout the h period. This suggests that the diel studies could have contributed to the increase in the effectiveness of daytime spill during the summer.

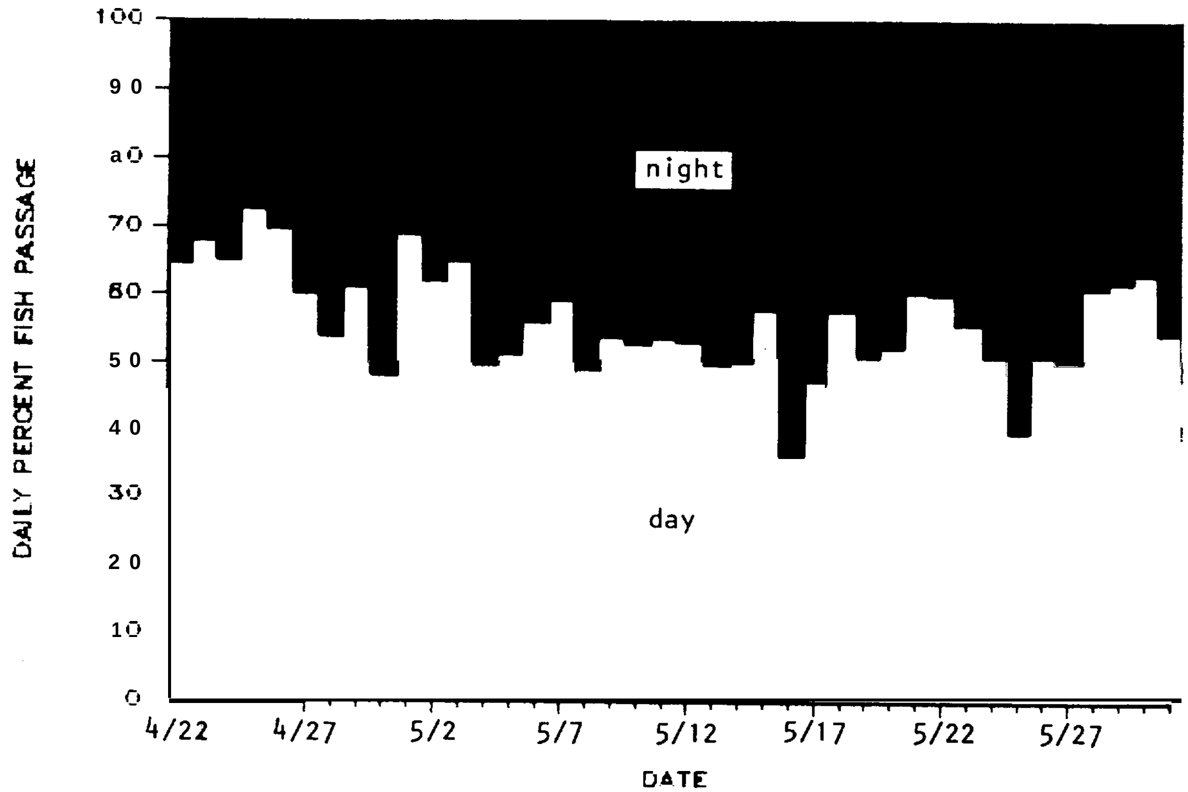

Figure 24. Daily percentage of fish passed during daytime (0600-2000 h) and nighttime (2000-0600 h) during the 40 day spring study period. The Dalles Dam, 1985.

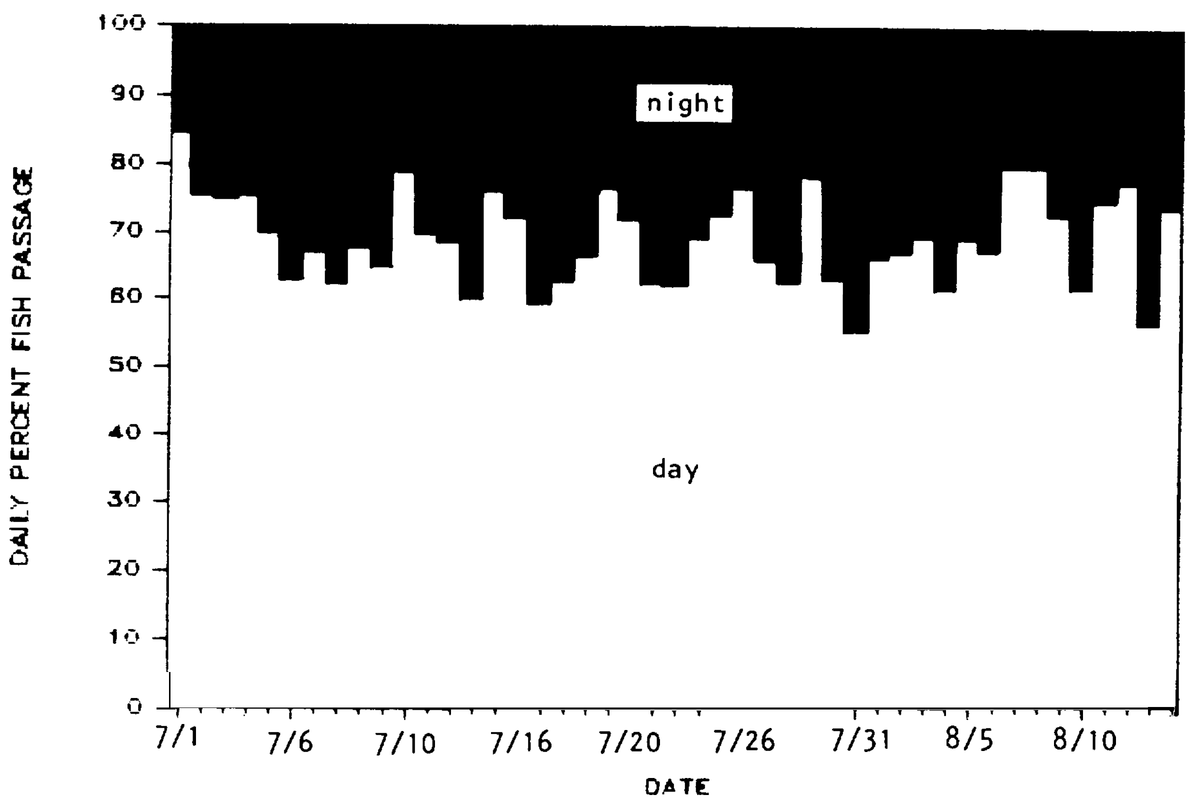

Figure 25. Daily percentage of fish passed during daytime (0600-2000 h) and nighttime (2000-0600 h) during the 45 day summer study period. The Dalles Dam, 1985

Table 7. Relative fish passage for the 14 h daytime and 10 h nighttime periods during the spring and summer study. The Dalles Dam, 1985.

	Date	% Day	% Night	Average Day	Percent Night
	4/22	64.58	35.42		
	4/23	67.74	32.26		
Block 1	4/24	65.98	34.02	68.13	31.87
	4/25	72.67	27.33		
	4/26	69.68	30.32		
	4/27	60.65	39.35		
	4/28	53.39	46.61		
Block 2	4/29	61.17	38.83	58.33	41.67
	4/30	47.81	52.19		
	5/01	68.65	31.35		
	5/02	62.02	37.98		
	5/03	64.72	35.28		
Block 3	5/04	49.76	50.24	56.67	43.33
	5/05	51.00	49.00		
	5/06	55.86	44.14		
	5/07	59.33	40.67		
	5/08	48.62	51.38		
Block 4	5/09	53.63	46.37	53.56	46.44
	5/10	52.87	47.13		
	5/11	53.36	46.64		
	5/12	53.04	46.96		
	5/13	49.09	50.91		
Block 5	5/14	49.47	50.53	49.04	50.96
	5/15	57.63	42.37		
	5/16	35.99	64.01		
	5/17	46.77	53.23		
	5/18	57.36	42.64		
Block 6	5/19	50.68	49.32	53.47	46.53
	5/20	51.94	48.06		
	5/21	60.60	39.40		
	5/22	60.08	39.92		
	5/23	55.24	44.76		
Block 7	5/24	50.80	49.20	51.31	48.69
	5/25	39.56	60.44		
	5/26	50.89	49.11		
	5/27	49.36	50.64		
	5/28	60.75	39.25		
Block 8	5/29	61.82	38.18	57.74	42.26
	5/30	63.00	37.00		
	5/31	53.75	46.25		
	7/01	83.74	16.26		
	7/02	75.17	24.83		

Table 7, (cont.)

	Date	% Day	% Night	Average Day	Percent Night
Block 9	7/03	74.83	25.17	75.93	24.07
	7/04	75.57	24.43		
	7/05	70.36	29.64		
	7/06	62.73	37.27		
	7/07	67.00	33.00		
Block 10	7/08	62.44	37.56	65.04	34.96
	7/09	67.90	32.10		
	7/10	65.15	34.85		
	7/11	79.13	20.87		
	7/12	69.65	30.35		
Block 11	7/13	68.71	31.29	70.89	29.11
	7/14	60.59	39.41		
	7/15	76.39	23.61		
	7/16	72.87	27.13		
	7/17	59.65	40.35		
Block 12	7/18	63.32	36.68	67.92	32.08
	7/19	66.55	33.45		
	7/20	77.22	22.78		
	7/21	72.32	27.68		
	7/22	63.31	36.69		
Block 13	7/23	62.63	37.37	68.15	31.85
	7/24	69.57	30.43		
	7/25	72.91	27.09		
	7/26	77.34	22.66		
	7/27	66.50	33.50		
Block 14	7/28	63.37	36.63	70.04	29.96
	7/29	78.87	21.13		
	7/30	64.10	35.90		
	7/31	55.86	44.14		
	8/01	66.90	33.10		
Block 15	8/02	67.93	32.07	64.72	35.28
	8/03	70.05	29.95		
	8/04	62.84	37.16		
	8/05	69.67	30.33		
	8/06	67.88	32.12		
Block 16	8/07	80.45	19.55	74.30	25.70
	8/08	80.21	19.79		
	8/09	73.31	26.69		
	8/10	62.93	37.07		
	8/11	75.20	24.80		
Block 17	8/12	78.33	21.67	69.62	30.38
	8/13	57.29	42.71		
	8/14	74.37	25.63		

3.4 Objective 4: Horizontal Distribution of Migrants across the Powerhouse and the spillway

3.4.1 Introduction

Estimates of the horizontal distribution of migrants across the powerhouse indicate where bypass efforts could be concentrated to maximize the effectiveness of fish bypass alternatives.

The horizontal distribution of migrants across the spillway indicates the relative efficiency of each gate in passing fish. This information may be useful for enhancing fish passage through the spillway.

3.4.2 Methods

Two horizontal distributions were calculated for both the powerhouse and the spillway. The first distribution included data collected during the 40 d spring study and the second distribution included data collected during the 45 d summer study.

The powerhouse was monitored with 15° transducers in front of Units 1, 3, 9, 13, 16, and 22.
15° transducers in front of spill Gates 1, 2, 3, 7, 12, 17, 21, and 23. The fish passage rate for the unmonitored turbine units or spill gates was estimated by linearly interpolating results from the monitored locations. Interpolated values are presented since
effectiveness of fish passage through the spillways, sluiceways, and turbines.

For more information on methods used for estimating horizontal distributions, see Appendix D.

3.4.3 Powerhouse Results and Discussion

The distribution of migrants across the powerhouse is shown in Figure 26 for the spring study and in Figure 27 for the summer study. During the spring study unit 3 passed the most fish and

units.

During the summer study, Units 3 and 22 passed nearly equal percentages of fish. The smaller, subyearling chinook passing during the summer season were believed to have been more shore oriented. This could have contributed to the greater percentage of fish passing through Unit 22, which is the unit nearest to the south shore of the river.

All the powerhouse horizontal distributions for each 5 d block of the spring and summer studies are presented in Tables H1 and H2, Appendix H.

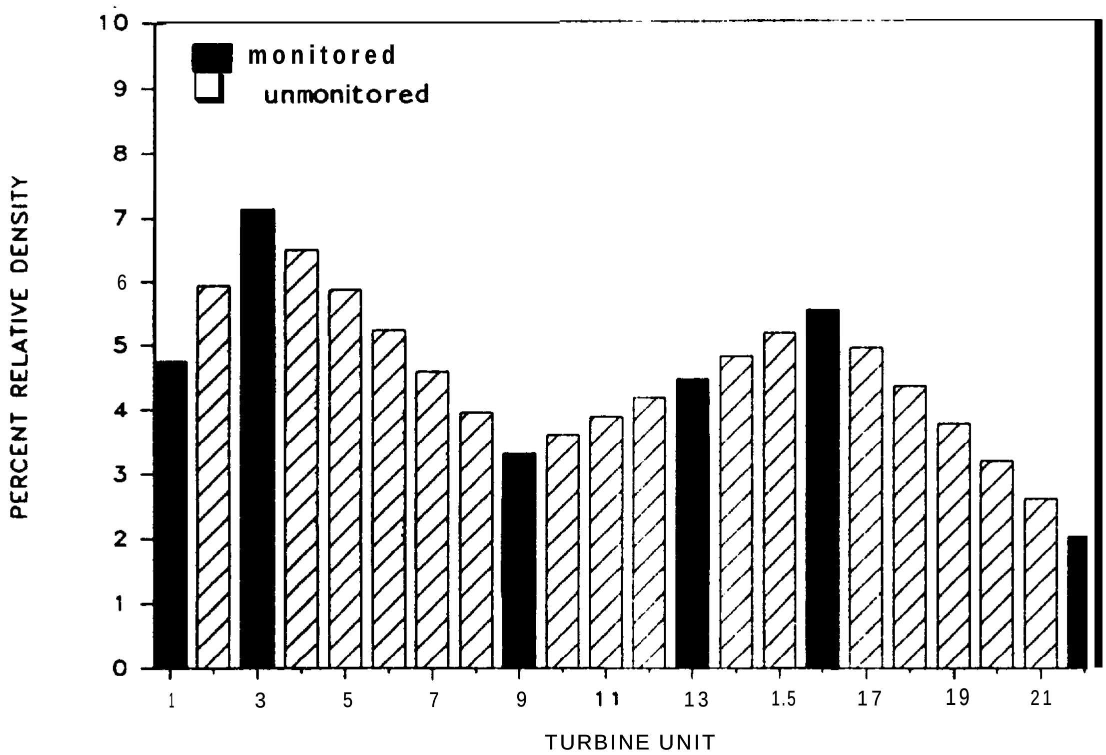

Figure 26. Horizontal distribution of fish passage across the powerhouse during the spring study period. The Dalles Dam, 1985.

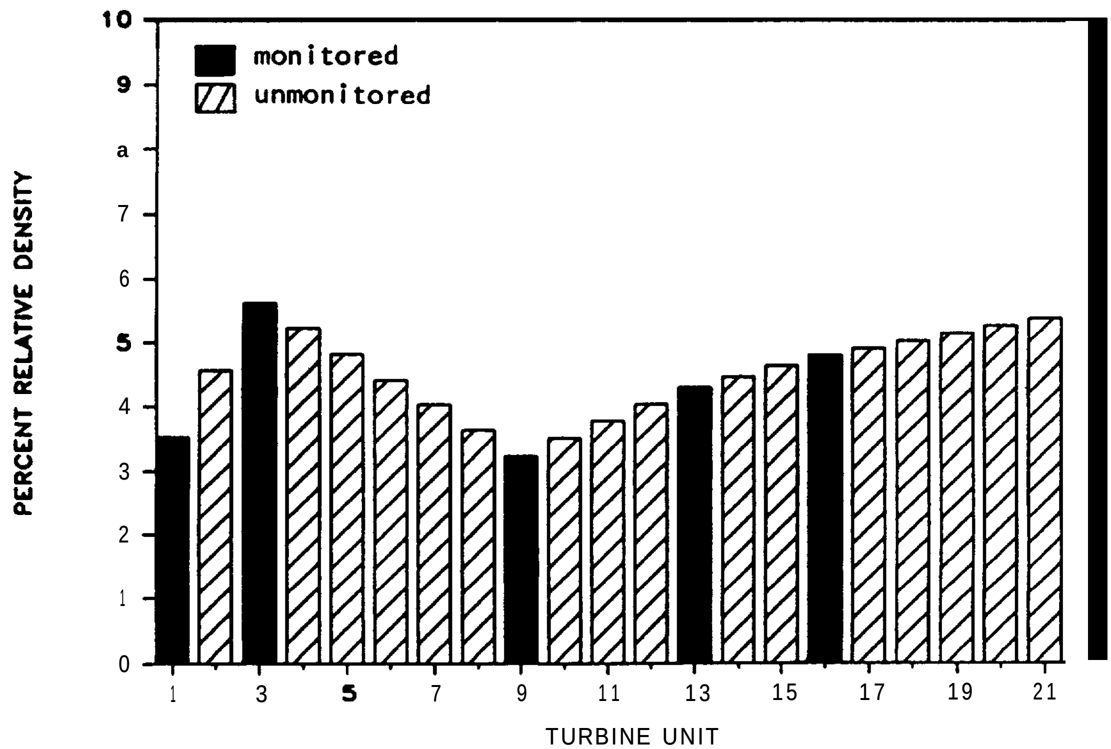

Figure 27. Horizontal distribution of fish passage across the powerhouse during the summer study period. The Dalles Dam, 1985.

3.4.4 Spillway Results and Discussions

The distribution of migrants across the spillway is shown in Figures 28 'and 29 for the spring and summer study, respectively. The spring distribution shows a relatively even distribution with a decrease at both ends of the spillway, except for an increase at Spill Gate 1. The summer distribution showed peaks at the center and both ends of the spillway. The summer distribution could have been influenced by the small flows through the spillway.

The spillway horizontal distributions for all the individual blocks are presented in Tables H3 and H4, Appendix H.

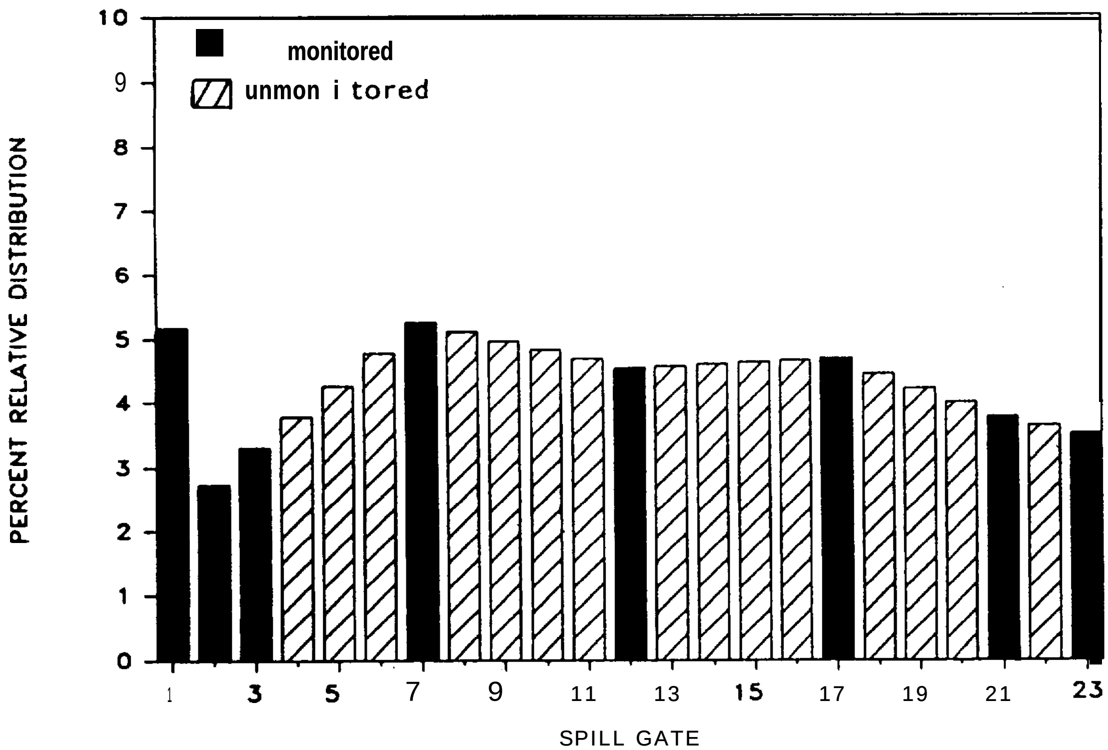

Figure 28. Horizontal distribution of fish passage across the **spillway during** the spring study period. The Dalles Darn, 1985.

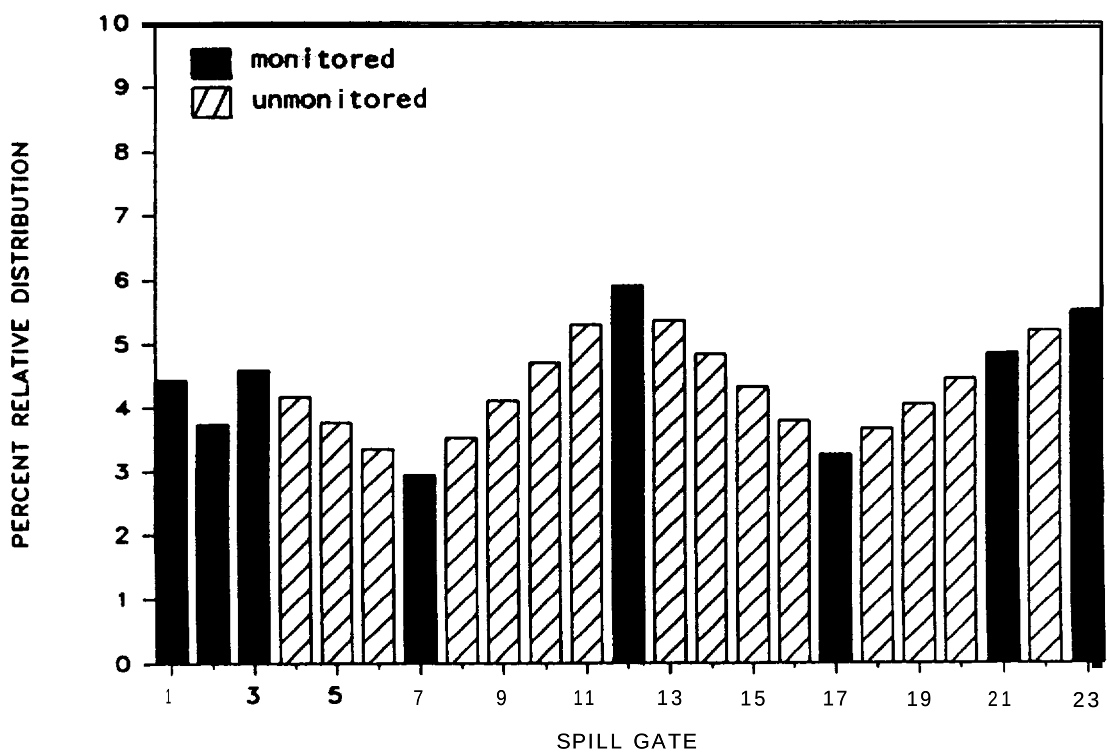

Figure 29. Horizontal distribution of fish passage across the spillway during the summer study period. The Dalles Dam, 1985.

3.5 objective 5: vertical Distributions of Migrants Passing through Turbines and Spill Gates

3.5.1 Introduction

vertical distributions provide useful information about migrants* behavior as they approach the dam. The effectiveness of any fish passage mechanism, including spill, depends on where in the water column fish are concentrated relative to that mechanism.

3.5.2 Methods

Range from the transducer was measured and recorded for each migrant detected at The Dalles Dam in 1985. Distributions along the transducer axes were combined for all monitored turbine units (powerhouse vertical distribution) and for all spill gates (spill-way vertical distribution). Only data with no acoustical or electrical interference were included in these distributions. All vertical distributions were generated using 15° transducers. Cumulative percentage distribution functions were developed using fish abundance estimates weighted by the effective beamwidth at the range each migrant was detected. Appendix D, Section D.3 describes the method in greater detail. Distributions were calculated for both spring and summer study periods.

3.5.3 Powerhouse Results and Discussion

Plots of daytime and nighttime composite cumulative percentage distributions for all the turbines can be found in Figures 30 and 31 for the spring and summer study, respectively. The vertical distributions show that the fish were significantly higher in the water column during daytime than at night. This is consistent with numerous other studies at Columbia River dams that show the fish are deeper at night.

There was also a shift in the vertical distributions between the spring and summer study periods. The summer downstream migrants (subyearling chinook) were lower in the water column than the corresponding spring migrants. These results were similar to what was found at Priest Rapids Dam in 1983 (Raemhild, et al. 1984c). The individual daytime and nighttime vertical distribution for each block are presented in Figures I1-I38, Appendix I.

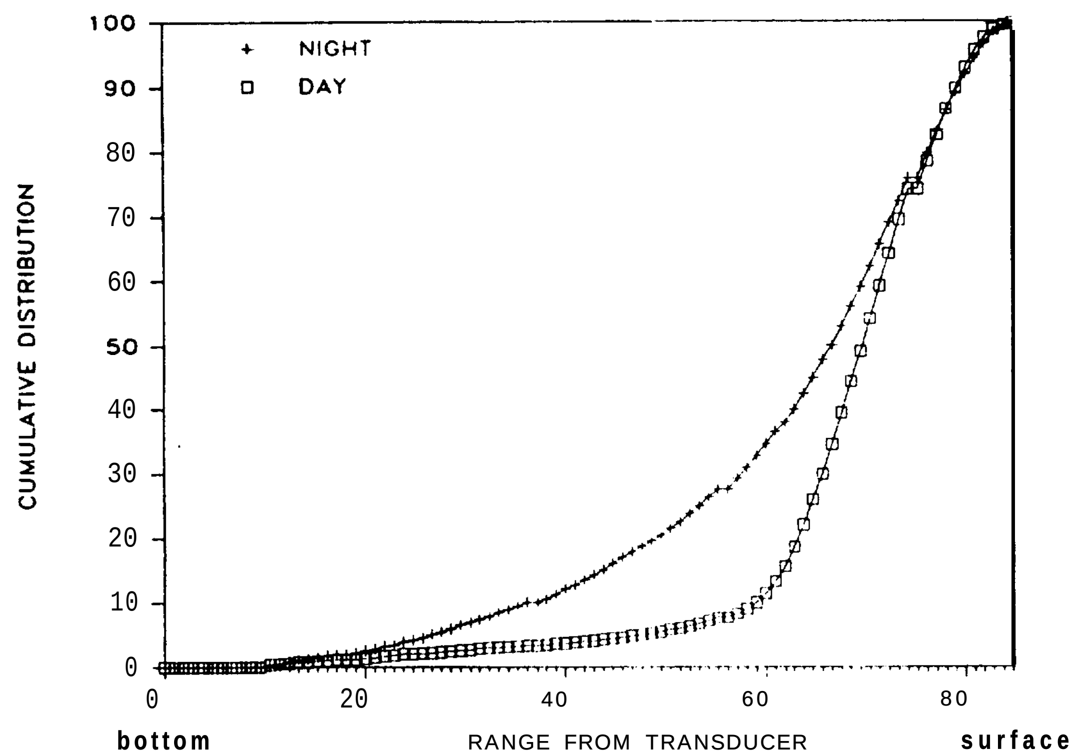

Figure 30. Empirical slant range distribution of migrants at the powerhouse during the spring study period. The Dalles Dam, 1985.

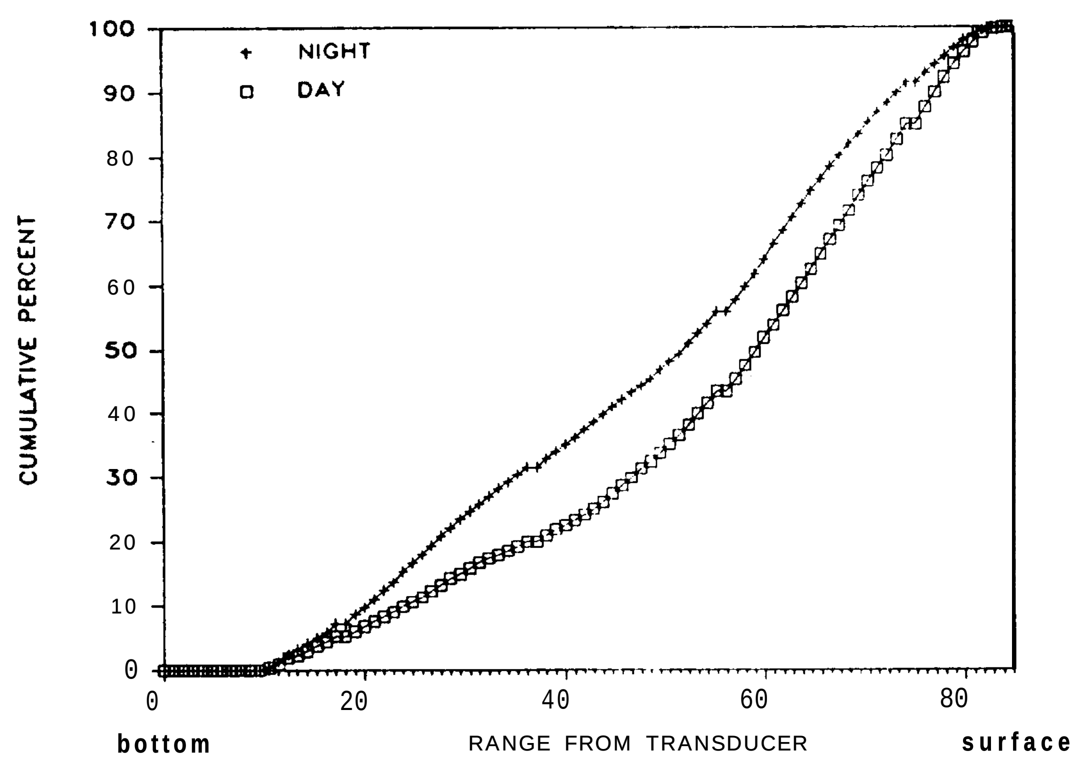

Figure 31. Empirical slant range distribution of migrants at the powerhouse during the summer study period. The Dalles Dam, 1985.

3.5.4 Spillway Results and Discussion

Plots of the composite spillway cumulative distributions for the spring and summer studies are presented in Figures 32 and 33, respectively. Again, the vertical distributions in the spillway were lower during the summer study than during the spring study. There were no nighttime vertical distributions since spill only occurred during the daytime. The individual block vertical distributions are presented in Figures 139-142, Appendix I.

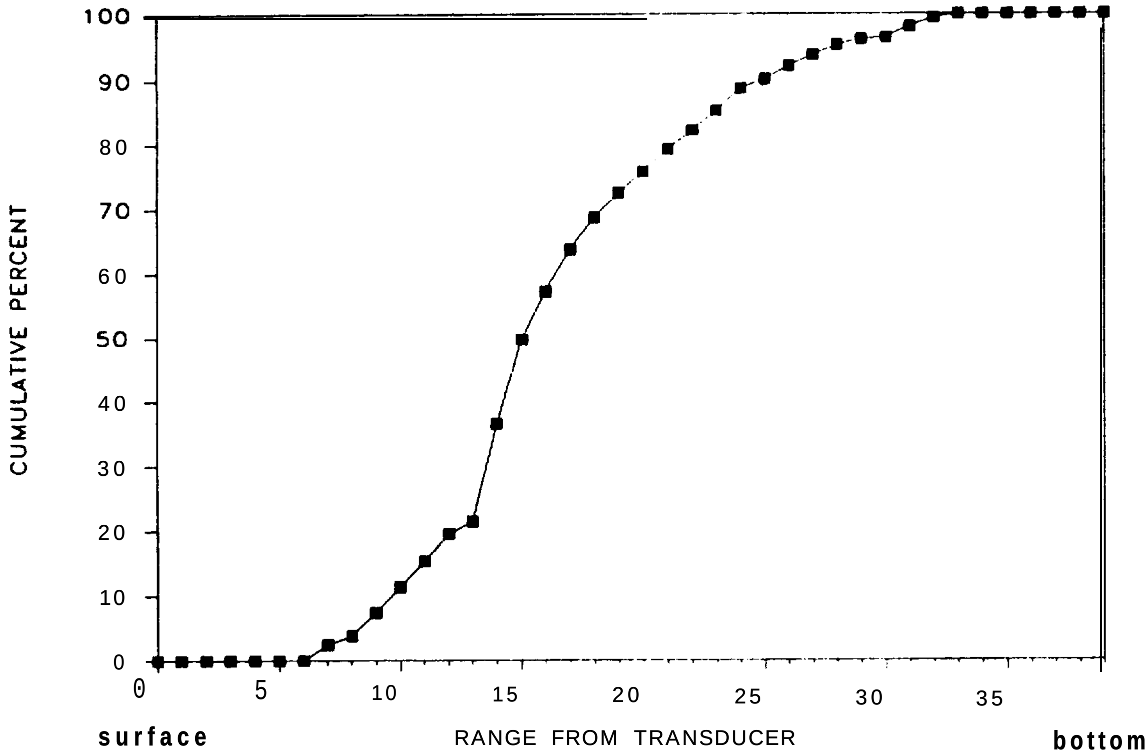

Figure 32. Rnpirical slant range distribution of migrants at the spillway during the spring study period. The Dalles Dam, 1985.

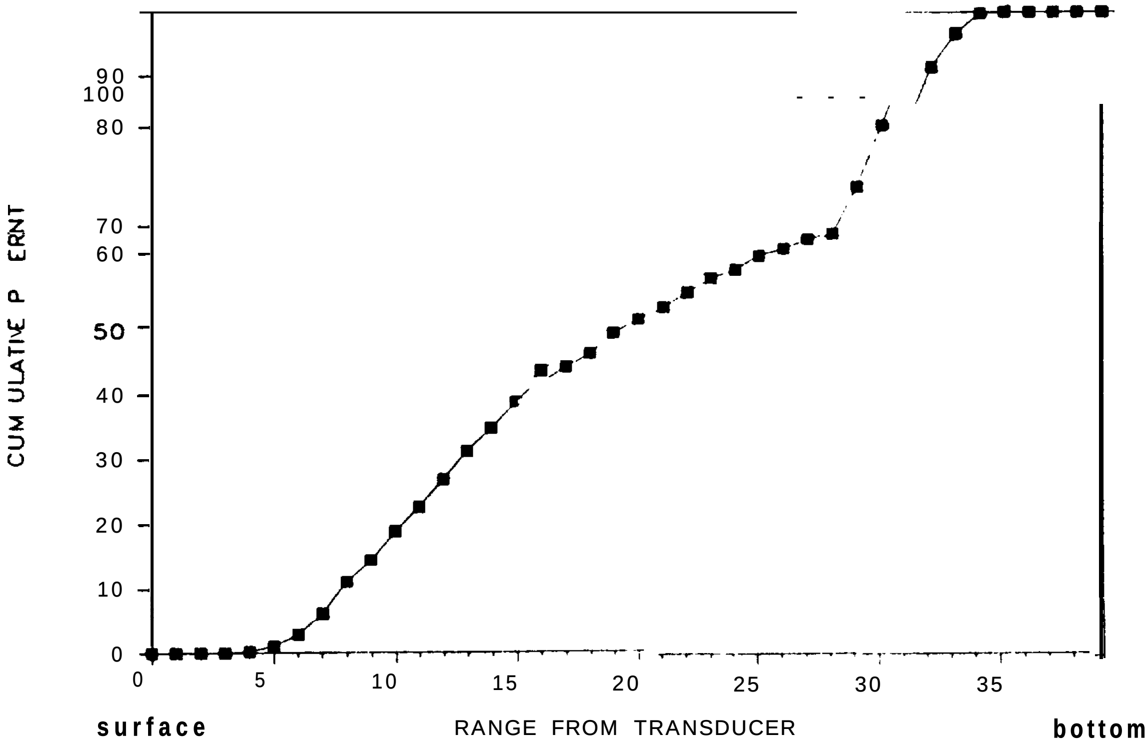

Figure 33. Empirical slant range distribution of migrants at the spillway during the summer study period. The Dalles Dam, 1985.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The 10 h instantaneous spill effectiveness results showed that spill passed fish more efficiently during the summer study than during the spring study. Respective spill levels of 17.8% and 21.8% for summer and spring results in summer and spring spill effectiveness estimates of 39.9% and 23.2%, respectively.

During the period May 1-31 when the turbines, spillway, and sluiceway were all operating consistently, the sluiceway was found to be the most efficient method of passing fish on a percent flow basis. Sluiceway fish passage was 23.2%, using an average of only 1.6% of the total average river (mean 24 h average). At the turbines, 67.7% of fish passed in 88.1% of the river flow. At the spillway, 9.2% of the fish passed in 10.3% of the river flow. During this period, the spillway was operated 10 h a day (0900-1900 h) and the turbines and sluiceway were operated 24 h a day.

During the summer study, after the termination of spill (July 11 to August 14), the sluiceway and turbines passed almost equal percentages of fish. The mean percent passage for the sluiceway and turbines for this period was 48.7% and 51.3%, respectively. Water flow into the sluiceway averaged 3.7% of the daily average river flow while the turbines used 96.3% of the daily average flow.

The run timing during the spring *study showed steadily increasing numbers of fish until the peak of the run on May 16. Another, smaller peak occurred on May 20. Thereafter, passage gradually decreased through the end of the spring study. The spring run consisted of yearling chinook, steelhead and sockeye juvenile salmonids. During the summer study, fish passage gradually decreased, except for minor peaks near the beginning of the study. The summer migration consisted primarily of subyearling chinook juvenile salmonids.

The vertical distributions of fish passage at the powerhouse showed that the fish were significantly higher in the water column during the daytime than at night for both the spring and summer studies. There was also a difference in distribution between the spring and summer studies with the summer migrants lower in the water column at both the powerhouse and spillway.

From May 7 to May 31 in the spring study, the average hourly fish passage for individual locations (turbines, sluiceway, and spillway) showed relatively higher passage during nighttime hours at the powerhouse. The sluiceway fish passage peaked near dawn (0400 h) following a drastic drop in fish passage at the power-house. This pattern of fish movement is very likely caused by both the increase of fish activity at dawn accompanied by a dramatic shift in the migrant vertical distribution.

From July 11 to August 14 in the summer study, average hourly fish passage at the turbines was relatively constant, with an evening peak around 2000-2200 h. Fish passage at the sluiceway was also relatively constant until 1900 h (the last hour of sluiceway operations) when a large peak occurred.

During the 40 d spring study, an average of 56.0% of the fish passed during the 14 h daytime (i.e., 58% of the 24 h) and 44.0% passed during the 10 h nighttime (42% of the 24 h). In contrast, during the 45 d summer study, an average of 69.6% of the fish passed during the daytime and 30.4% passed during the nighttime.

The daytime/nighttime results showed that during the spring study the fish passed continuously throughout the 24 h period in contrast to the summer study when the fish passed primarily during the daylight hours. This change in the diel distribution during the summer season could have contributed to the increase in the effectiveness in the summer daytime spill.

During the spring study, the horizontal distribution of fish across the powerhouse showed the most fish passing through Turbine Unit 3 and the least through unit 22. In contrast, Units 3 and 22 passed nearly equal percentages of fish during the summer study. The smaller subyearling chinook passing during the summer season were believed to be more shore-oriented. This could have contributed to the greater percentage of summer fish passing through unit 22, which is nearest the south shore of the river.

Many factors could have contributed to these differences between spring and summer. The summer season consisted primarily of subyearling chinook smolts, while the spring season consisted of chinook yearlings, steelhead and sockeye smolts. The magnitude of the spring run was greater than the magnitude of the summer run. Also, the river flow during the spring was as much as three times greater than the flow past the project during the summer.

This year's baseline study provided valuable insights into the horizontal, vertical, and temporal distributions of downstream migrants. It has also provided information on the effectiveness of passing fish through the spill and sluiceway. However, at other Columbia River dams there has been a large variability in the distribution and migration patterns of fish from year to year. It is recommended that further studies be performed to provide more information for different years.

The vertical distributions showed that the fish were deeper in the water column at night. Since the spillways open from the bottom upwards, this suggests that nighttime spill might be more efficient than daytime spill. This suggestion is supported by results of the summer study, where spill effectiveness increased as vertical distributions shifted deeper in the water column. It is recommended that a nighttime spill schedule be included in further spring-time studies.

TO better characterize the relationship between percent river spilled and percent fish passing in spill, a wide range of controlled spill levels should be tested. A 5 d spill block (with 5 different spill levels) repeated through the course of the study would allow evaluation of spill effectiveness at different spill levels, independent of seasonal factors.

The "in-season" index proved reasonably effective for tracking major trends in the migration. An in-season real-time index could be an effective management tool.

Finally, to better define the most efficient spill pattern, the use of fewer spill gates opened wider is recommended. As found at other Columbia River dams, spill effectiveness can be increased by a change in the spill gate operation.

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APPENDIX A: Hydroacoustic System Equipment, Operation, and Calibration

Equipment Description

Each of the basic BioSonics hydroacoustic data collection systems consisted of the following components: 420 **kHz** transducers, an echo sounder/transceiver, a multiplexer/equalizer, one or two chart recorders, and an oscilloscope. A video cassette tape recorder was also available for recording the echo sounder output for data backup and later laboratory analysis. A block diagram of the basic system is shown in Figure Al. Table Al lists specific manufacturers and model numbers of the electronic equipment used.

Table AI. Manufacturers and model numbers of electronic equipment used by BioSonics, Inc. at The Dalles Dam during the spring and summer 1985.

Item	Manufacturer	Model Number
Echo Sounder/transceiver	BioSonics, Inc.	101
High Speed Multiplexer/ Equalizer	BioSonics, Inc.	151
Chart Recorder Interface	BioSonics, Inc.	165
Chart Recorders	EPC	1600
	Raytheon	LSR-910M
Transducers (15°)	BioSonics, Inc.	SP06
Oscilloscope	Hitachi Denshi, Ltd.	V-352
Rotator (dual-axis)	BioSonics, Inc.	SPSOO
Rotator control box	BioSonics, Inc	SPSOO
Microcomputers	NorthStar	Advantage
	Northstar	Advantage HD
Computer Printers	Epson	FX-80
		MX-80

Note: Specifications for equipment can be obtained by contacting BioSonics, Inc.

Equipment Operation

The hydroacoustic data collection system works as follows: when triggered by the Model 101 Echo Sounder, a high-frequency transducer emits short sound pulses in a relatively narrow beam aimed toward an area of interest. As these sound pulses encounter fish or other targets, echoes are reflected back to the transducer which then reconverts the sound energy to electrical signals. The signals are then amplified by the echo sounder at a time-varied-gain (TVG) which compensates for the loss of signal strength due to absorption and geometric spreading of the acoustic beam with distance from the transducer. Thus, equally-sized targets produce the same signal amplitudes at the echo sounder output regardless of their distance from the transducer. A target's range from the transducer is determined by the timing of its echo relative to the transmitted pulse.

The echo sounder relays the returning TVG-amplified signals to the chart recorder and the oscilloscope. The return signals are visually displayed on the oscilloscope for measurements of echo strengths and durations. Individual fish traces are displayed on the chart recorder's echograms which provide a permanent record of all targets detected throughout the study. The threshold circuit on the chart recorder eliminates signals of strengths less than the echo levels of interest.

The Model 151 Multiplexer/Equalizer (MPX/EQ) permits a single echo sounder to automatically interrogate up to 16 different transducers in an operator-specified sequence. The MPX/EQ channels transmit pulses from the echo sounder to the appropriate transducers and equalizes the return signals to compensate for the differing receiving channel sensitivities resulting from varying cable lengths, etc. In the "fast multiplexed mode" the MPX/EQ permits "simultaneous* interrogation of two transducers with the return TVG-amplified signals routed to two separate chart recorders.

System Calibration

The acoustic system was calibrated before the study began. Calibration assured that an echo from a target of known acoustic size passing through the axis of the acoustic beam produced a specific output voltage at the echo sounder. Once this voltage was known, an accurate (+ 0.5°) estimate of the actual sensivity beamwidth (or "effective" beam width) for a given target strength could be determined for each transducer based on sensivity plots.

Based on the calibration information, the adjustable print threshold on the chart recorder was set so that it would print signals from targets larger than -50 dB. This minimum target strength corresponded to the smallest juvenile salmonids expected during the study (approx. 5.7 cm) according to the target strength-size relationship established by Love (1971). The calibration information was also used to equalize (on the MPX/EQ) the systems' sensitivities for each receiving channel. A detailed description of the calibration of hydroacoustic systems can be found in Albers (1965) and Urich (1975).

APPENDIX B: Data Acquisition Procedures

Migrant Detection Criteria

Echogram traces had to satisfy three criteria to be classified as downstream migrants: (1) the strength of target echoes had to exceed a predetermined threshold; (2) the targets had to be detected by consecutive pulses (redundancy); and (3) the targets had to show general movement toward the intake.

Target Threshold

The data collection system was calibrated so that the chart recorder would mark targets with target strengths greater than -50 dB within the specified beamwidth of the transducer. This target strength threshold was chosen so that even the smallest migrants anticipated would return an echo with an amplitude great enough to mark the echogram.

Target Redundancy

At least four successive ensonifications were required for a target to be classified as a fish. Most of the fish observed were sequentially detected more than four times. The reasons for this high redundancy were: 1) the relatively wide beamwidths of the transducers; 2) the high pulse repetition rates; and 3) the behavior of the fish (fish appeared to be moving at about the same velocity as the water). This redundancy criterion enhanced fish detectability in the presence of background interference and was necessary to obtain sufficient change-in-range information to determine direction of fish travel.

Direction of Movement

Since transducers were in fixed locations at aiming angles that were not perpendicular to the direction of fish travel, it was possible to distinguish fish moving toward the intake from those moving away. Only fish moving toward the dam were classified as downstream migrants. As a fish passed through an ensonified volume, a succession of echoes on the echogram indicated a fish's change-in-range relative to the transducer. Since the transducer's positioning was known, this change-in-range information expressed the fish's direction of movement relative to the intake. Figure Bl shows typical fish movement through an ensonified volume, and Figure B2 shows a corresponding echogram trace caused by such a fish.

Further details of fish detection criteria for fixed-location hydroacoustics can be found in Carlson et al. (1981).

Data Entry and Storage

Microcomputers were used for data storage and analysis. Data from individual fish observations recorded on the echograms were transformed to numeric data files on a microcomputer by using a digitizing pad and appropriate software. For each detected fish passing through the acoustic beam, a technician used the digitizing stylus to record the following:

- time of entrance
- time of exit
- range at entrance
- range at exit
- general direction of fish movement (trace type)

The following information was also recorded for each sampling sequence:

- date
- start time of transducer interrogation
- duration of transducer interrogation
- transducer location
- transducer depth
- transducer beamwidth
- transducer orientation
- background interference level
- background interference range

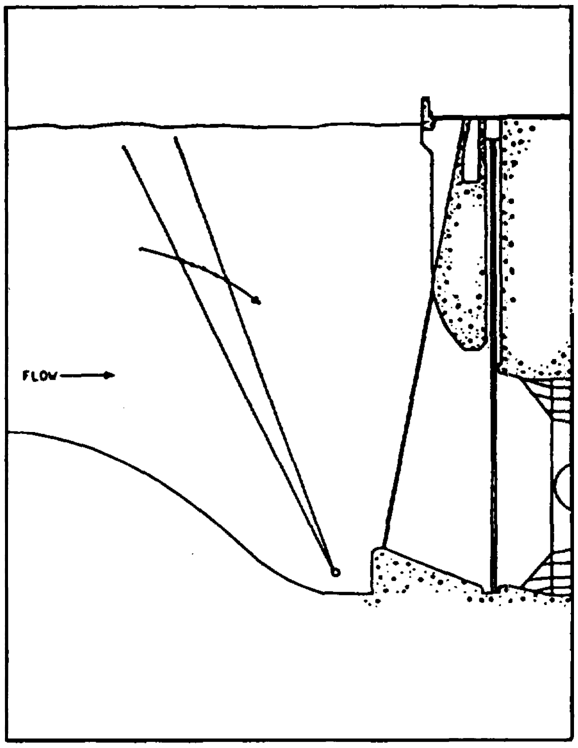


Figure B1. Typical trajectory of a fish with five detections passing through the region ensonified by a transducer.

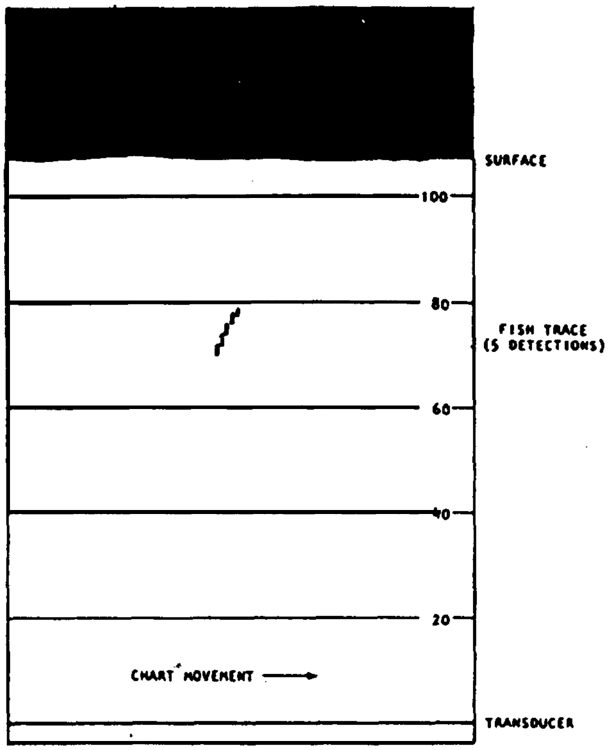


Figure B2. Sketch of an echogram with a five-detection fish trace showing typical change-in-range information.

APPENDIX C: Locations and Descriptions of Transducers and Mount Configurations used at The Dalles Dam during Spring and Summer 1985

Table Cl. Transducer locations, mount types, and orientations used at The Dalles Dam, spring and summer 1985.

Location	Surface/ Bottom Mount	Actual Beam **Width (deg)**	Mount Depth **(ft)**	Vertical Aiming Angle **(deg)**
Powerhouse				
T l	b	16	90	167
T 3	b	15	90	167
T 9	b	15	90	167
T 13	b	18	90	167
T 16	b	16	90	167
T 22	b	15	90	167
Spillway				
s 1	**s**	15	**5**	**0**
s 2	**s**	17	**5**	**0**
s 3	**s**	16	**5**	**0**
s 7	**s**	16	**5**	**0**
s 12	**s**	16	**5**	**0**
s 17	**s**	16	**5**	**0**
s 21	**s**	16	**5**	**0**
S 23	**s**	16	**5**	**0**
Sluiceway				
L l-l	b	16	15	190
L l-2	b	15	15	190
L l-3	b	15	15	190

APPENDIX D: Data Analysis

Computer programs were developed by **BioSonics,** Inc. to facilitate analysis of spill effectiveness, diel periodicity, run timing, horizontal distributions, and vertical distributions.

D.l Extrapolation of Data Affected by High Interference

Periodically, acoustical or electrical interference ("noise") obscured portions of echograms, thus preventing accurate detection of fish and resulting in biased estimates of fish passage rates. In order to compensate for obscured fish traces, an extrapolation based on the distribution of fish from unobscured periods was applied.

Cumulative "standard" distributions along the transducer axis were derived from data not affected by interference. Estimates of weighted fish from these standard distributions were used to extrapolate for those portions of the data obscured by interference.

Location was found to be a more important factor than time in determining the shape of a vertical distribution. standard cumulative vertical distributions were created (whenever possible) for each location by five-day block and by daytime and nighttime period using unobscured data. Data from adjacent sampling locations were combined only when there was an insufficient number of detections from an individual sampling location.

Each sequence which displayed high acoustical interference was then extrapolated. Any visible fish which occurred in the obscured portion were ignored, and fish in the unobscured portion of the echogram were summed. The standard vertical distribution was consulted to determine the percentage of fish which should have occurred in the noisy part of the echogram, had there been no noise. The number of fish estimated to have occurred in the obscured part of the echogram was calculated by:

$$\left(\frac{F_u}{F_s/100}\right) \qquad (1)$$

where

F_o = obscured weighted fish

F_u = unobscured weighted fish

F_s = percent of fish in the segment of the standard distribution corresponding to the unobscured portion of the echogram being extrapolated.

In this way only unbiased data was used to establish standards for estimating obscured (and possibly biased) portions of echograms. Since each noisy sequence (transducer interrogation) was extrapolated individually, all available unobscured data was utilized for extrapolation.

D.2 Method for Estimating Passage Rates

Procedure

The initial hydroacoustic data set consisted of midpoint ranges for each migrant detected. Since the beam did not ensonify the whole area in front of a turbine or spill intake, not all the fish passing into that intake were detected. The total number of migrants passing into an intake at a particular range and instant was estimated by multiplying each detection by the proportion of the intake cross section ensonified at that migrant's range. This dimensionless weight was simply the ratio of the horizontal dimension of the intake to the diameter of the beam at that depth. Based on this weight, each detected downstream migrant represented an estimate of the number of migrants entering the intake at that range and instant of detection.

Theory and Mathematics

The proportion of an intake cross-section that was hydroacoustically sampled was a function of the following variables: range from the transducer (due to spreading of the transmitted acoustic wave with distance); the beam pattern of the transducer; the target properties of the migrants; the acoustic energy transmitted; and the sensitivity of the hydroacoustic system. A discussion of how these variables interrelate to determine effective beamwidth is beyond the scope of this study, but is dealt with in detail by others (Urick 1975).

For the transducers monitored at The Dalles Dam, the effective beamwidth at a given range from a transducer was calculated by:

$$A(r) = 2\ r\ \tan\ (a) \qquad (2)$$

where

$A(r)$ = the effective beamwidth at range r

r = range from the transducer

a = transducer effective beam half angle
(see Appendix C for transducer beam width)

The proportion of a turbine intake sampled at a specific range from a particular transducer was estimated from

$$P(r) = \frac{A(r)}{B(r)} \qquad (3)$$

where

$P(r)$ = proportion of the turbine intake sampled

$B(r)$ = intake width at range r (in this case a constant).

Assuming that the horizontal distribution of fish is constant across the entire turbine intake, the weighting factor $W(r)$ is equal to the inverse of the proportion of the turbine intake sampled:

$$W(r) = \frac{1}{P(r)} \qquad (4)$$

An estimate of the number of fish passing into a turbine intake for each transducer sampling sequence was estimated by:

$$N_t = \sum_{j=1}^{m} D_j W_j \qquad (5)$$

where

N_t = the estimated number of fish entering the entire turbine intake t during each transducer sampling sequence

D_j = actual number of detected fish within the range j increment

m = maximum range increment (strata) of detected fish

W_3 = weighting factor at range j.

The total number of fish entering a turbine intake per day and night during the time when a transducer was being interrogated was estimated from:

$$F_t = \sum_{k=1}^{L} N_{tk} \tag{6}$$

where

F_t = the total estimate of fish entering the turbine intake t during all the transducer sampling sequences per day and night

L = total number of sequences sampled per time block

N_{tk} = estimated number of fish entering the entire turbine intake t during time block k.

During data collection and all analysis phases, care was taken to exclude all data collected when a turbine was off-line or a spill gate was closed. Operations data was recorded in increments of 60 minutes.

D.3 Method for Calculating Diel Periodicity at the Powerhouse

Diel distributions were examined in three ways: daily, on a 14 h (daytime) and 10 h (nighttime) basis; by 5 d block on an hourly basis for each location; and by 5 d block on an hourly basis for all locations combined. For the daily 14 h/10 h block estimates, the total estimated number of fish entering each intake during the time of interrogation for that time block (F_t in Equation 6) was expanded to account for the total time the intake was operated during the time block. These estimates were then summed over all turbine intakes and spill gates to obtain a total project passage estimate for each 14 h/10 h block. The estimated percentage passed during each 14 h/10 h block was then calculated by dividing each 14 h/10 h block estimate by the sum of the total project passage of both day and night 14 h/10 h time blocks and multiplying by 100.

Hourly estimates were calculated in the same way except that the block size was 1 h instead of 14 h/10 h. The general method is described by:

$$P_b = \sum_{t=1}^{n} \left(F_t \times \frac{T_b}{T_m} \right) + \sum_{s=1}^{n} \left(F_s \times \frac{T_b}{T_m} \right) + \sum_{l=1}^{n} \left(F_l \times \frac{T_b}{T_m} \right) \tag{7}$$

where

P_b = total passage for the 1 h or 14 h/10 h time block

t = operating turbine number

n = maximum number of operating turbines or spill gates or sluice gates

F_t = total estimate of fish entering the turbine intake t during all the transducer sampling sequences per time block

T_b = total time turbine or spill gate or sluice gate was operated during the time block

T_m = total time turbine or spill gate or sluice gate was monitored during the time block

s = operating spill gate number

F_s = total estimate of fish entering the spill gate during all the transducer sequences per time block.

1 = operating sluice gate number

F_1 = total estimate of fish entering the sluice gate during all the transducer sequences per time block.

The percent passage was then calculated by:

$$\%D = \frac{P_{bi}}{\sum_{i=1}^{n} P_{bi}} \times 100 \qquad (8)$$

where

$\%D$ = percent diel passage for the given time block

i = time block number

n = number of time blocks.

D.4 Method for Estimating the Horizontal Distributions at the Powerhouse and Spillway

Horizontal distributions across the powerhouse and the spillway were calculated using data from periods when monitored turbines/spill gates were running approximately 100% of the time. Two distributions were created for the powerhouse and the spillway; one which included data from April 22-May 31 (spring study) and a second distribution which included data from July 1-August 14 (summer study). The summer spillway horizontal distribution included data from July l-July 5 (the time period when all spill gates were in operation). In the spill, only data from the daytime periods were included since spill occurred only during the daytime.

After first correcting for acoustical interference and weighting factor (described in Sections D.1 and D.2 above), daily daytime and nighttime rates of fish/min were calculated for each monitored, operational turbine and spill gate. Daily daytime rates were calculated by:

$$R_{jdx} = \frac{N_{jdx}}{M_{jdx}} \tag{9}$$

where

R_{jdx} = the passage rate (fish/min) at intake j, on day x

N_{jdx} = the number of migrants detected at intake j on day x

M_{jdx} = the number of minutes intake j was monitored on day x.

Daily nighttime rates were calculated using:

$$R_{jnx} = \frac{N_{jnx}}{M_{jnx}} \tag{10}$$

where

R_{jnx} = the passage rate (fish/min) on night x,

N_{jnx} = the number of migrants detected at intake j on night x

M_{jnx} = the number of minutes intake j was monitored on nightx.

Since not all operating turbines and spill gates were monitored, interpolation for unmonitored locations was neccessary. Therefore, linear interpolation was used to estimate the unmonitored locations.

D.5 Method for Calculating the Vertical (Slant Range) Distribution Function

The first step in estimating vertical distributions was to determine the depth (or the slant range) of each detected fish based on the echogram traces. Each fish was assigned to a one-foot wide depth stratum along the transducer's acoustic axis (i.e. along the aiming angle of the transducer). Each fish detection was weighted inversely as a function of slant range, using the following formula:

$$W_j = \frac{K}{L_j} \tag{11}$$

where

W_j = weighted fish j

L_j = slant range of fish j

K = weighting factor constant.

The percentage of fish detections for each slant range was calculated by:

$$P_{ij} = \frac{W_{ij}}{\sum_{j}^{n} \sum_{i}^{n} W_{ij}} \tag{12}$$

where

P_{ij} = the percentage each weighted fish represents of the total weighted fish detection

W_{ij} = weighted fish j in stratum i.

The percentage of weighted fish in each slant range stratum was then summed by:

$$S_i = \sum_{j}^{n} P_{ij} \tag{13}$$

where

S_i = percentage each stratum represents of the total weighted fish detected.

The vertical distribution function is the cumulative percentage of each slant range stratum, summed with increasing range from the transducer. Surface-mounted transducers were treated the same as those mounted on the bottom. All vertical distribution functions were oriented from transducer to maximum range, regardless of whether the transducer was bottom- or surface-mounted.

APPENDIX E: Spill and Sluice Effectiveness

Spill/sluice effectiveness was defined as the percentage of fish passed in spill/sluice relative to total fish passing the dam. The 24 h sluice effectiveness results are presented in Tables El (spring) and E2 (summer). The 10 h instantaneous and 24 h daily average spill effectiveness results for the spring study are presented in Figures El and E2, respectively. The 10 h instantaneous and 24 h daily average spill effectiveness results for the summer study are presented in Figures E3 and E4, respectively. The best fit linear regression model (passing through the origin) was calculated for the spill effectiveness data points **(Zar,** 1974). These regression lines are presented in Figures El-E4.

The daily proportion of total project fish passage through the spillway on a 10 h and 24 h basis is presented in Figure **E5** for the spring study and Figure E6 for the summer study. The daily proportion of total project fish passage through the sluiceway on a 24 h basis is presented in Figure E7 for the spring study and Figure E8 for the summer study.

Table El. Sluice fish passage estimates for spring study. The Dalles Dam, 1985.

Date		Percent Fish	Average % Fish	Percent River	Average % River
4/22		37.6		1.5	
4/23		46.9		2.1	
4/24	Block 1	42.8	39.4	1.4	1.6
4/25		44.3		1.5	
4/26		25.3		1.6	
4/27		No Data		2.2	
4/28		No Data		1.9	
4/29	Block 2	No Data		1.5	1.8
4/30		No Data		1.6	
5/01		14.0		1.7	
5/02		19.7		1.7	
5/03		21.4		1.5	
5/04	Block 3	14.8	19.2	1.9	1.6
5/05		12.6		1.6	
5/06		27.6		1.3	
5/07		26.5		1.5	
5/08		22.1		1.6	
5/09	Block 4	26.5	24.3	1.7	1.5
5/10		20.9		1.4	
5/11		25.2		1.5	
5/12		32.7		1.6	
5/13		19.0		1.4	
5/14	Block 5	33.7	27.5	1.6	1.6
5/15		31.7		1.9	
5/16		20.3		1.5	
5/17		19.6		1.8	
5/18		20.1		1.7	
5/19	Block 6	19.6	20.8	1.7	1.7
5/20		20.9		1.6	
5/21		23.9		1.6	
5/22		23.0		1.6	
5/23		17.6		1.7	
5/24	Block 7	21.4	21.5	1.5	1.6
5/25		20.2		1.6	
5/26		25.3		1.6	
5/27		21.7		1.6	
5/28		28.7		1.5	
5/29	Block 8	29.1	27.8	1.5	1.6
5/30		40.2		1.6	
5/31		19.1		1.6	

Table E2. Sluice fish passage estimates for summer study. The Dalles Dam, 1985.

Date		Percent Fish	Average % Fish	Percent River	Average % River
7/01		7.0		2.7	
7/02		9.2		2.3	
7/03	Block 9	9.1	11.3	2.2	2.6
7/04		16.0		2.9	
7/05		15.4		3.0	
7/06		11.7		2.9	
7/07		20.1		3.1	
7/08	Block 10	18.5	17.1	3.2	3.2
7/09		18.6		3.5	
7/10		16.8		3.0	
7/11		28.6		3.1	
7/12		28.7		3.3	
7/13	Block 11	48.5	41.4	2.1	3.5
7/14		36.4		4.2	
7/15		64.7		4.7	
7/16		61.9		4.4	
7/17		42.3		3.1	
7/18	Block 12	35.9	48.9	2.9	3.4
7/19		39.6		3.0	
7/20		64.8		3.4	
7/21		59.0		3.5	
7/22		53.3		4.3	
7/23	Block 13	41.7	47.8	3.8	3.8
7/24		52.9		3.5	
7/25		32.1		3.7	
7/26		58.5		4.3	
7/27		59.5		5.0	
7/28	Block 14	51.8	53.1	5.5	4.8
7/29		49.5		4.3	
7/30		45.9		4.9	
7/31		43.0		4.4	
8/01		53.1		3.8	
8/02	Block 15	49.6	48.6	3.5	3.9
8/03		46.8		3.6	
8/04		50.3		4.3	
8/05		44.2		3.4	
8/06		42.7		3.3	
8/07	Block 16	67.5	52.9	4.0	3.7
8/08		54.3		3.1	
8/09		55.7		4.5	
8/10		50.8		4.6	
8/11		66.0		5.0	
8/12	Block 17	58.6	48.0	3.8	4.2
8/13		27.3		4.3	
8/14		37.4		3.5	

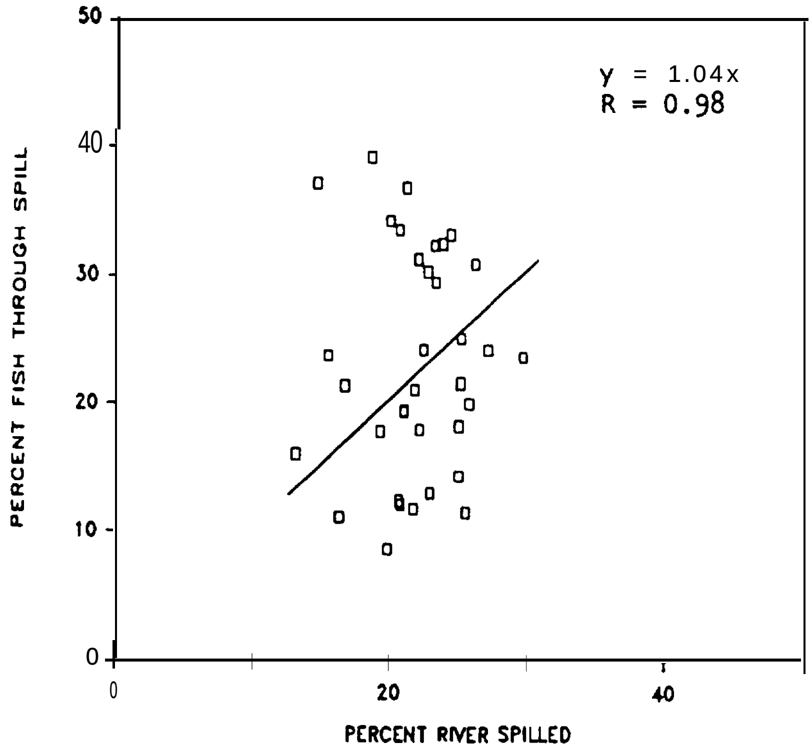


Figure El. Spring 10 h instantaneous spill effectiveness with the best fit linear regression line passing through zero . The Dalles Dam, 1985.

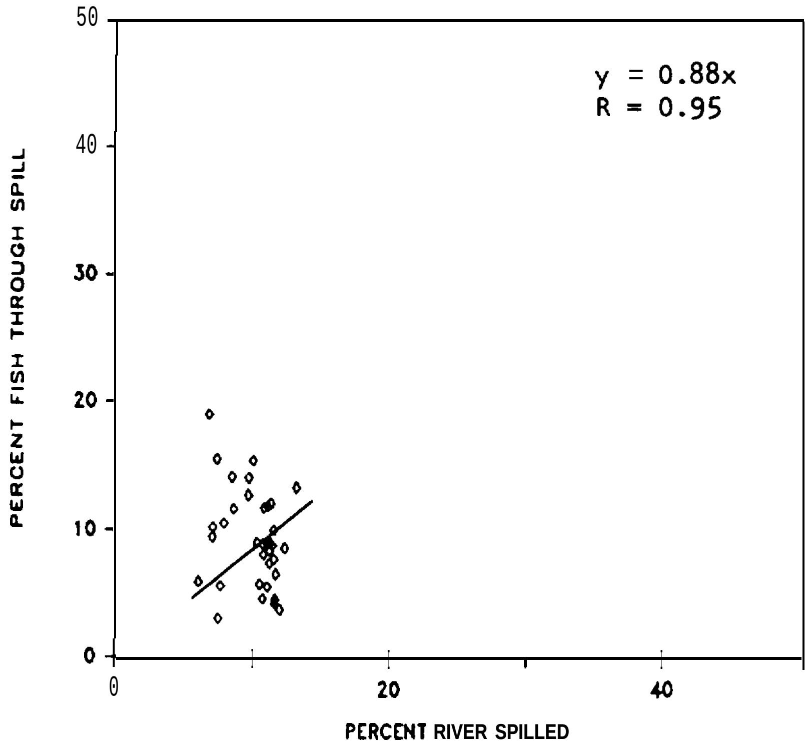


Figure E2. Spring 24 h daily average spill effectiveness with the best fit linear regression line passing through zero. The Dalles Dam, 1985.

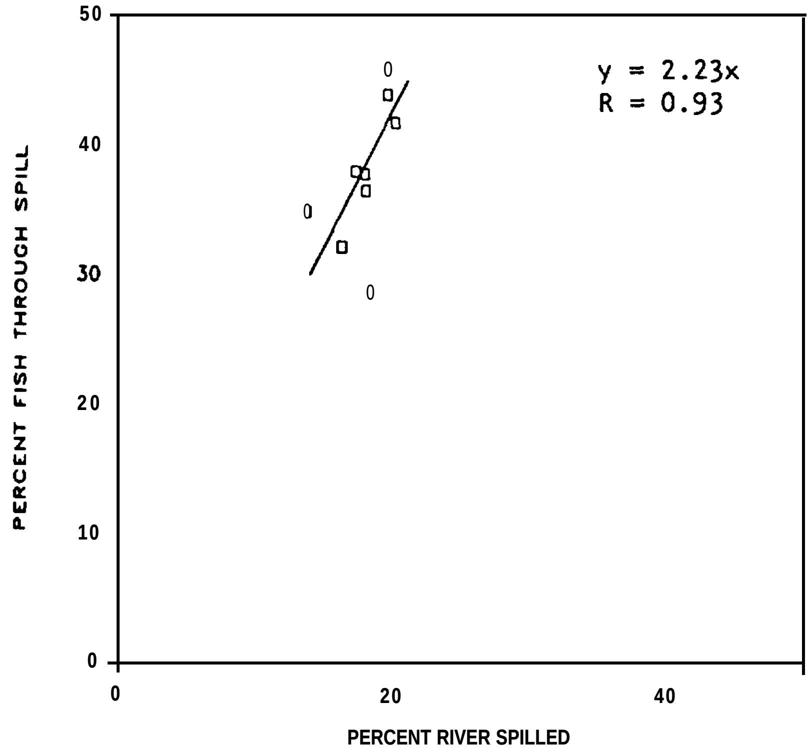


Figure E3. Summer 10 h instantaneous spill effectiveness with the best fit linear regression line passing through zero . The Dalles Dam, 1985.

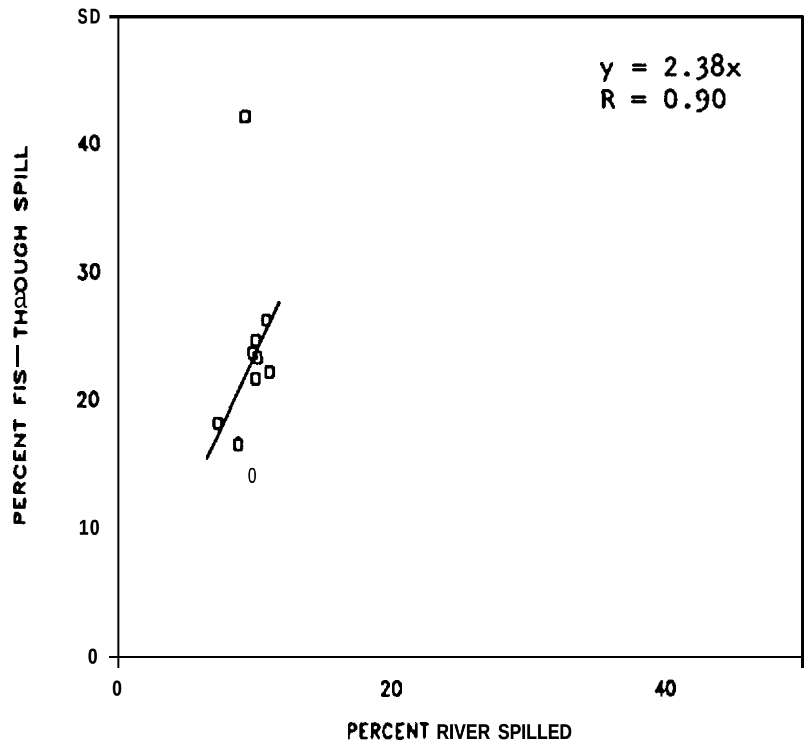


Figure E4. Summer 24 h daily average spill effectiveness with the best fit linear regression line passing through zero. The Dalles Dam, 1985.

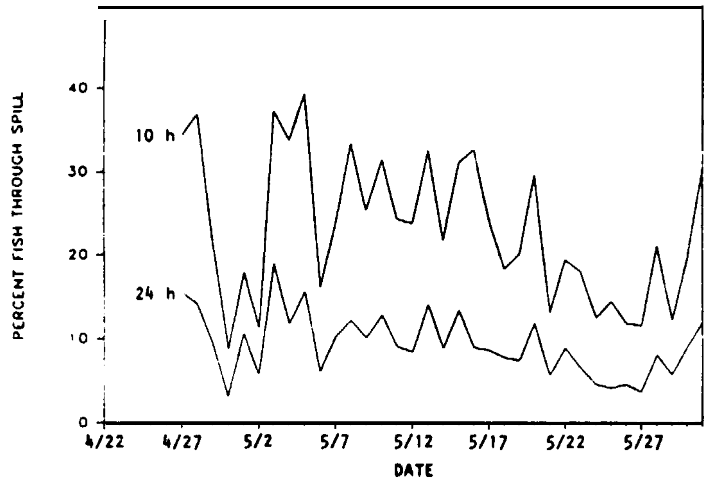


Figure E5. Spring 10 h and 24 h percent spill fish passage. The Dalles Dam, 1985.

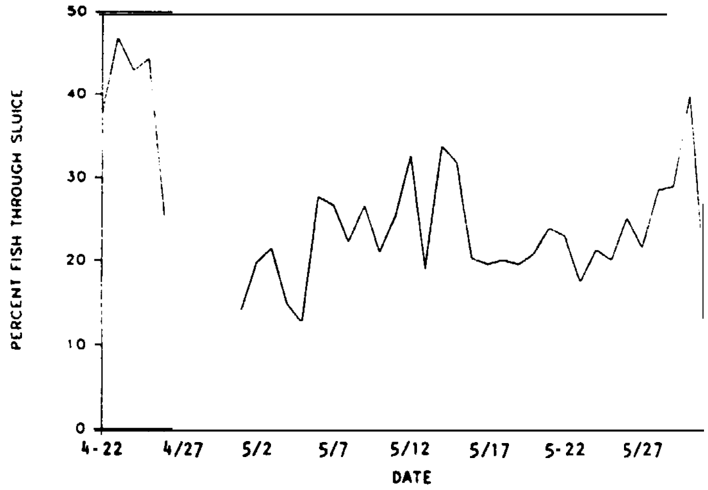


Figure E7. Spring 24 h daily percent sluice fish passage. The Dalles Dam. 1985.

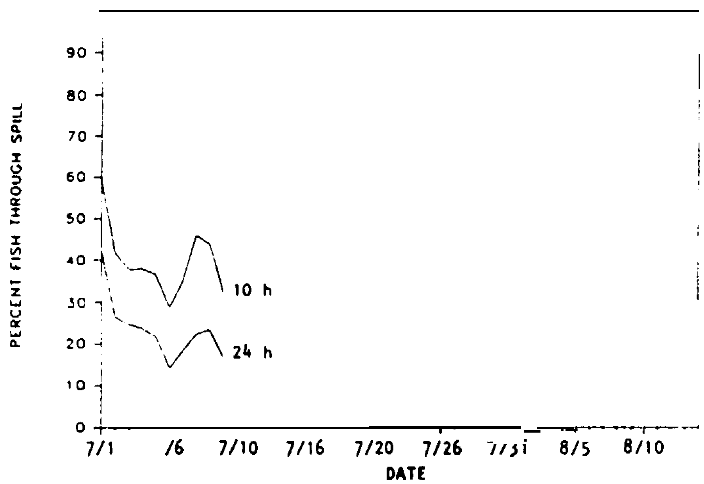


Figure E6. Summer 10 h and 24 h percent spill fish passage. The Dalles Dam, 1985.

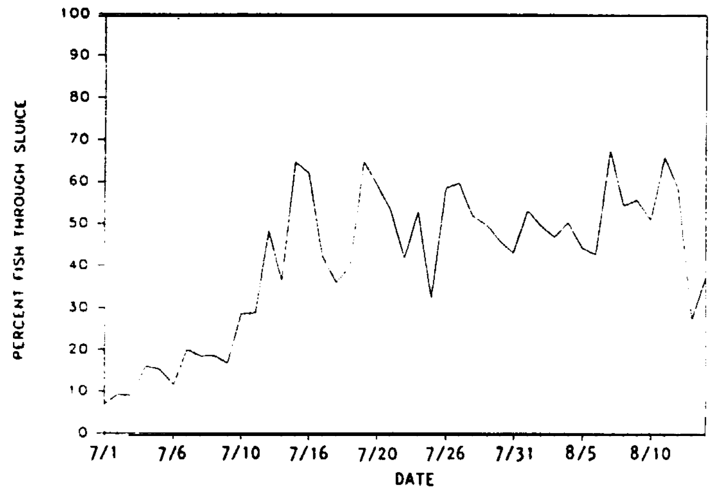


Figure E8. Summer 24 h [illegible]ily percent sluice fish passage for summer. The [illegible]lles Dam 1985.

APPENDIX F: Species Compositon, Run Timing and Seasonal Flow

The species composition from the John Day Dam smolt index as reported in the Water Budget Weekly Reports for the spring season is presented in Table F1 and in Table F2 for the summer season. The project river outflow for each location (turbines, sluice gates and spill gates) are presented in Tables F3 and F4 for the spring and summer studies, respectively.

Scatter plots of estimated run timing against the in-season index are provided in Figures Fl-F2 for spring and summer, respectively. The relationship for spring is highly correlated, while that for summer less so. The best fit linear regression model (passing through the origin) was calculated for these data points (Zar, 1974). These regression lines are presented in Figures Fl-F2.

Since dam operations for summer differed markedly from the high run-off spring period, the relationship which was held relatively constant during the spring underwent significant changes during the summer period, reducing the effectiveness of the in-season run timing index.

The daily total project river outflows for each study period (spring and summer) are shown in Figures F3 and F4.

Table F1. Species Composition derived from the John Day Dam smolt index. Based on Water Budget Center weekly reports, spring 1985.

Date	Chinook 1	Chinook 0	steelhead	sockeye
4/27	48.2	0.0	44.7	7.0
4/28	44.2	0.0	46.8	9.0
4/29	39.3	0.0	50.2	10.6
4/30	49.7	0.0	34.4	15.8
5/01	55.0	0.2	24.0	20.9
5/02	59.6	0.3	21.1	19.0
5/03	47.6	0.1	36.2	16.1
5/04	46.6	0.0	32.2	21.2
5/05	31.9	0.2	50.6	17.3
5/06	34.8	1.3	37.1	26.9
5/07	33.4	0.1	37.3	29.1
5/08	44.8	0.4	31.8	22.9
5/09	54.0	.o	32.3	13.6
5/10	54.0	0.1	28.3	17.6
5/11	73.7	0.1	17.2	9.0
5/12	61.1	0.3	24.7	13.9
5/13	64.5	0.2	20.4	14.8
5/14	67.4	0.2	20.9	11.6
5/15	73.1	0.1	19.8	7.0
5/16	64.8	0.2	22.3	12.7
5/17	71.1	0.4	16.9	11.6
5/18	60.7	0.3	33.2	5.9
5/19	67.3	0.3	25.2	7.2
5/20	50.8	0.3	41.0	7.9
5/21	53.7	0.2	39.9	6.2
5/22	55.5	0.2	35.2	9.1
5/23	55.1	0.4	37.4	7.1
5/24	65.7	0.5	24.3	9.6
5/25	61.9	0.2	27.6	10.3
5/26	46.7	0.5	42.9	9.9
5/27	49.5	0.8	34.2	15.5
5/28	46.3	1.3	29.8	22.5
5/29	75.5	1.4	14.9	8.2
5/30	36.6	0.5	45.1	17.8

Table F2. Species composition derived from the John Day Dam smolt index. Based on Water Budget Center weekly reports, summer, 1985.

Date	Chinook 1	Chinook 0	Steelhead	Sockeye
7/01	1.0	94.3	3.9	0.7
7/02	0.6	95.0	3.2	1.2
7/03	0.7	96.8	2.3	0.2
7/04	1.0	96.3	1.8	1.0
7/05	0.7	97.8	0.9	0.6
7/06	3.0	91.4	4.1	1.5
7/07	1.3	96.0	1.9	0.8
7/08	1.0	97.9	0.7	0.4
7/09	1.8	96.9	1.2	0.1
7/10	0.7	98.1	0.4	0.8
7/11	0.8	97.8	0.9	0.6
7/12	0.4	99.0	0.3	0.4
7/13	1.0	98.7	0.0	0.2
7/14	0.8	98.9	0.2	0.1
7/15	0.2	99.2	0.6	0.1
7/16	0.3	99.7	0.1	.o
7/17	.o	99.9	.o	0.0
7/18	0.1	99.6	0.2	0.1
7/19	.o	99.9	0.0	.o
7/20	0.1	99.6	0.3	0.0
7/21	.o	99.8	0.1	.o
7/22	0.1	99.9	.o	0.0
7/23	0.1	99.8	.o	.o
7/24	0.1	99.8	.o	0.1
7/25	.o	99.9	0.0	0.1
7/26	.o	99.6	0.1	0.2
7/27	0.1	99.8	0.1	0.0
7/28	.o	99.9	0.0	.o
7/29	0.0	99.9	.o	0.1
7/30	.o	99.9	.o	0.0
7/31	0.5	99.5	.o	.o
8/01	0.1	99.8	0.0	.o
8/02	0.1	99.9	.o	.o
8/03	0.0	99.9	0.1	0.0
8/04	0.0	99.2	0.8	0.0
8/05	0.0	99.8	0.1	0.1
8/06	0.0	99.8	0.2	0.0
8/07	0.2	99.3	0.5	0.0
8/08	0.4	98.7	0.8	0.0
8/09	0.4	97.1	2.5	0.0
8/10	0.0	96.9	3.1	0.0
8/11	0.0	98.5	1.5	0.0
8/12	0.0	99.0	0.7	0.3
8/13	0.0	98.9	1.1	0.0
8/14	0.0	98.4	1.6	0.0

Table F3. Total project river outflow (kcf/10E6) for the spring study. The Dalles Dam, 1985.

Date	Turbine Flow	Spill Flow	Sluice Flow	Total Flow
4/22	16.35	0	0.26	16.61
4/23	14.88	0	0.32	15.19
4/24	18.03	0	0.26	18.29
4/25	21.10	0	0.32	21.42
4/26	19.51	0	0.32	19.83
4/27	12.75	1.46	0.32	14.53
4/28	15.31	1.46	0.32	17.08
4/29	18.70	1.46	0.32	20.47
4/30	17.56	1.46	0.32	19.34
5/01	16.57	1.46	0.32	18.34
5/02	17.19	1.46	0.32	18.97
5/03	19.54	1.46	0.32	21.31
5/04	15.09	1.46	0.32	16.86
5/05	17.85	1.46	0.32	19.63
5/06	22.17	1.46	0.32	23.95
5/07	18.67	1.46	0.32	20.45
5/08	16.99	2.21	0.32	19.53
5/09	16.67	2.21	0.32	19.20
5/10	20.26'	2.21	0.32	22.79
5/11	18.88	2.21	0.32	21.41
5/12	17.15	2.21	0.32	19.68
5/13	20.21	2.21	0.32	22.74
5/14	16.83	2.21	0.32	19.37
5/15	14.24	2.21	0.32	16.77
5/16	18.01	2.21	0.32	20.54
5/17	15.39	2.21	0.32	17.92
5/18	15.79	2.10	0.32	18.21
5/19	16.39	2.11	0.32	18.82
5/20	17.00	2.10	0.32	19.42
5/21	17.03	2.16	0.32	19.50
5/22	17.46	2.21	0.32	19.99
5/23	16.20	2.19	0.32	18.71
5/24	19.17	2.34	0.32	21.83
5/25	17.36	2.32	0.32	19.99
5/26	17.49	2.35	0.32	20.15
5/27	16.82	2.33	0.32	19.47
5/28	18.66	2.30	0.32	21.27
5/29	18.52	2.21	0.32	21.05
5/30	17.08	2.21	0.32	19.61
5/31	17.39	2.21	0.32	19.92

Table F4. Total Project **river** outflow **(kcf/10E6)** for the summer study. The Dalles Dam, 1985.

Date	Turbine Flow	Spill Flow	Sluice Flow	Total Flow
7/01	10.31	1.08	0.32	11.71
7/02	11.72	1.46	0.32	13.50
7/03	12.70	1.46	0.32	14.47
7/04	9.55	1.08	0.32	10.94
7/05	9.33	1.08	0.32	10.73
7/06	9.59	1.08	0.32	10.98
7/07	9.23	0.76	0.32	10.30
7/08	8.35	1.08	0.32	9.75
7/09	7.76	0.92	0.32	8.99
7/10	9.17	0.92	0.32	10.40
7/11	9.78		0.32	10.09
7/12	9.43		0.32	9.74
7/13	14.83		0.32	15.14
7/14	7.30		0.32	7.62
7/15	6.39		0.32	6.70
7/16	6.80		0.32	7.12
7/17	9.80		0.32	10.12
7/18	10.45		0.32	10.77
7/19	10.33		0.32	10.64
7/20	8.99		0.32	9.31
7/21	8.67		0.32	8.99
7/22	7.05		0.32	7.37
7/23	8.03		0.32	8.35
7/24	8.63		0.32	8.94
7/25	8.34		0.32	8.66
7/26	6.99		0.32	7.31
7/27	5.98		0.32	6.30
7/28	5.45		0.32	5.77
7/29	7.07		0.32	7.38
7/30	6.11		0.32	6.42
7/31	6.87		0.32	7.19
8/01	7.94		0.32	8.26
8/02	8.69		0.32	9.01
8/03	8.37		0.32	8.68
8/04	7.09		0.32	7.41
8/05	9.05		0.32	9.36
8/06	9.25		0.32	9.56
8/07	7.60		0.32	7.91
8/08	9.75		0.32	10.07
8/09	6.75		0.32	7.07
8/10	6.57		0.32	6.89
8/11	5.97		0.32	6.29
8/12	8.06		0.32	8.38
8/13	7.09		0.32	7.41
8/14	8.80		0.32	9.11

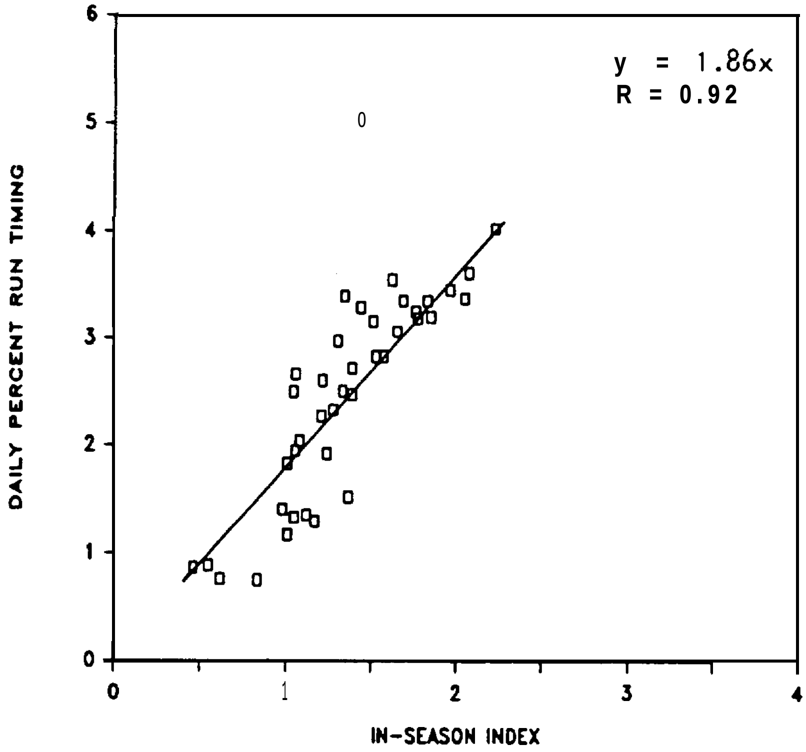


Figure F1. Estimated spring run timing compared to the "in-season" indices with best fit linear regression line passing through zero. The Dalles Dam, 1985.

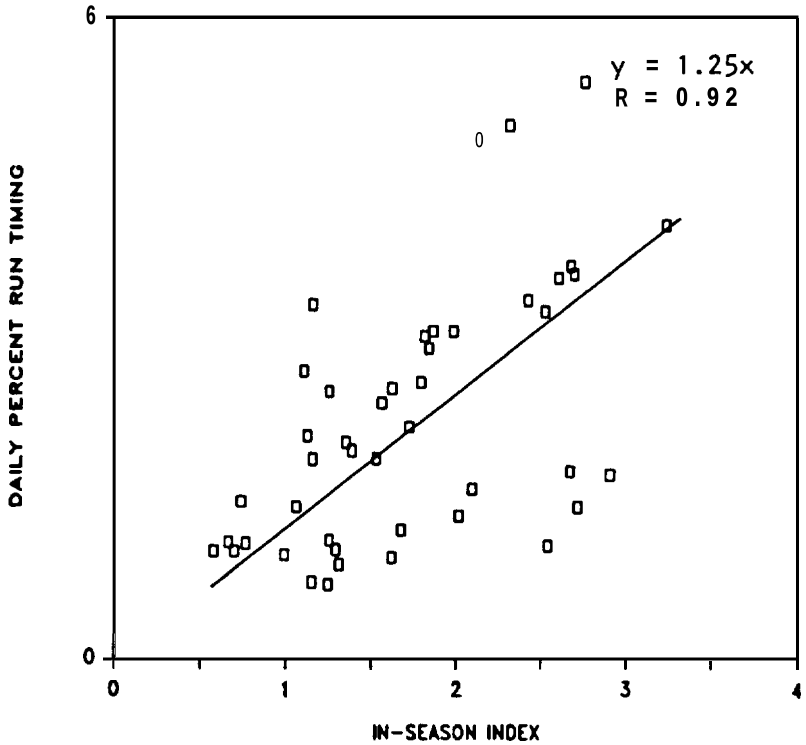


Figure F2. Estimated summer run timing compared to the "in-season" indices with best fit linear regression line passing through zero. The Dalles Dam, 1985.

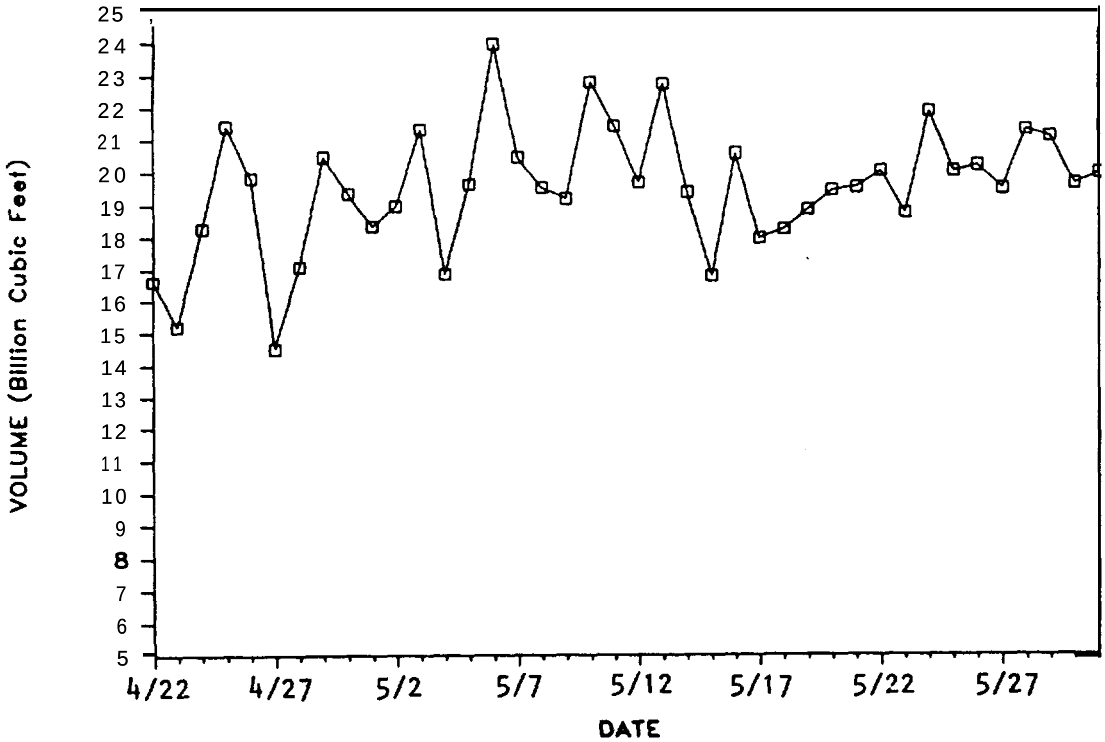


Figure F3. Daily spring total project river flow.

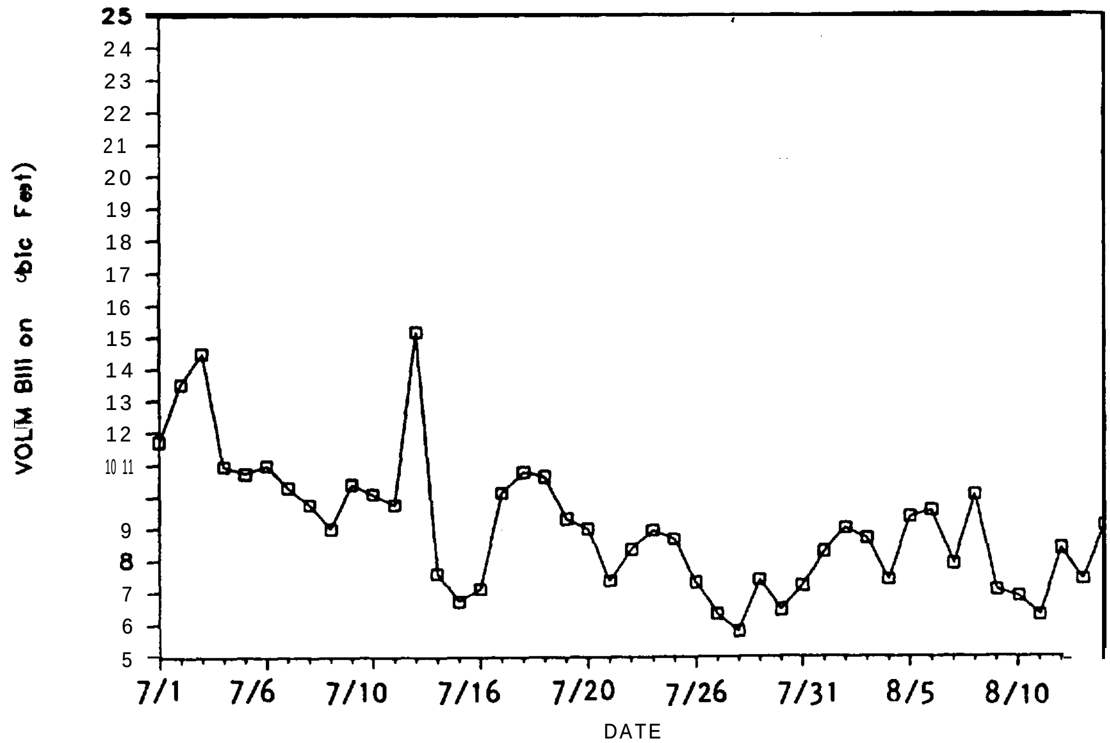


Figure F4. Daily summer total project river flow.

APPENDIX G: Hourly Die1 Distribution by Time Block

Hourly die1 distributions were calculated by the method described in Appendix D, section D.3. The hourly percent passage for each block of the 40 d spring study is presented in Table G1 and for the 45 d summer study is presented in Table G2. Figures G1 through G51 provide overall diel distributions on an hourly basis for each block by; (1) fish passage for all locations combined, (2) project river flow; and (3) fish passage for each location individually.

TABLE G1. Average diel fish passage percentages by block for the spring study. The Dalles Dam, 1985.

Hour	BLOCK 1	2	3	4	5	6	7	8
8	4.82	3.18	3.19	3.92	3.32	4.56	4.48	4.18
9	4.33	5.38	5.69	5.95	4.80	5.85	5.31	4.97
10	4.90	5.35	5.22	6.54	5.86	6.58	5.10	5.95
11	5.06	4.61	3.72	5.83	4.29	5.43	5.29	5.03
12	4.72	4.48	4.09	4.63	4.54	5.30	3.71	4.14
13	4.51	4.02	3.53	4.15	4.12	3.98	3.57	5.32
14	4.75	4.14	3.94	3.06	2.81	3.57	3.78	4.66
15	3.84	3.51	3.41	2.61	2.99	3.28	3.69	3.46
16	3.45	3.78	3.93	2.13	2.29	2.71	3.28	3.04
17	5.43	3.71	2.73	2.73	2.28	3.00	3.01	2.92
18	3.72	5.46	4.59	3.37	3.64	2.79	2.80	3.22
19	8.61	4.19	5.22	2.57	2.25	1.28	2.14	2.67
20	5.38	6.34	8.76	7.71	7.18	8.75	8.65	5.96
21	3.53	5.33	5.05	4.99	4.85	4.71	9.91	9.54
22	4.84	5.45	4.78	5.01	5.47	4.27	4.15	5.14
23	2.87	2.58	3.77	4.54	4.50	3.97	3.52	4.08
0	2.12	4.03	2.99	4.44	4.73	3.60	3.27	3.17
1	2.14	3.51	3.06	3.87	5.44	3.56	4.05	3.50
2	1.95	4.40	2.66	3.54	4.27	4.04	3.18	2.67
3	2.09	4.81	3.63	3.56	6.77	5.27	3.66	2.35
4	2.77	2.68	3.06	3.79	5.23	3.83	3.26	1.68
5	4.37	2.56	4.38	4.05	3.84	3.49	4.07	2.92
6	4.10	3.17	4.51	3.74	2.35	2.69	2.84	4.77
7	5.70	3.32	4.07	3.28	2.19	3.50	3.30	4.68

TABLE G2. Average diel fish passage percentages by block for the summer study. The Dalles Dam, 1985.

Hour	BLOCK 9	10	11	12	13	14	15	16	17
8	2.88	3.20	3.64	3.97	5.28	4.77	3.65	5.18	5.37
9	4.78	2.67	4.20	4.03	5.59	4.16	4.84	3.69	6.41
10	6.31	4.98	4.04	4.28	4.97	6.64	3.78	4.42	6.32
11	7.18	4.38	4.63	4.57	5.09	4.49	4.26	5.20	4.68
12	6.69	3.65	3.59	3.61	3.58	4.99	3.40	5.40	3.85
13	6.69	4.98	3.96	4.73	4.76	4.55	3.05	4.75	5.17
14	6.35	5.85	4.87	5.27	6.32	4.47	2.86	4.27	3.12
15	7.44	5.72	5.00	4.70	5.12	4.79	4.66	4.55	4.09
16	7.46	5.02	6.03	4.38	5.46	5.48	4.30	4.37	3.89
17	8.04	5.06	9.22	5.39	3.83	5.92	6.64	4.83	4.44
18	4.04	6.26	5.30	5.30	3.57	5.85	5.33	4.55	5.17
19	2.96	7.45	10.47	8.79	6.70	7.83	11.51	13.94	10.67
20	2.39	3.72	4.39	2.77	4.33	4.77	6.95	6.46	4.10
21	3.57	4.66	3.21	4.71	5.88	4.17	7.46	4.35	3.01
22	3.09	5.27	2.86	3.78	2.52	2.32	5.25	3.11	3.29
23	2.96	4.09	2.84	3.04	2.88	2.45	2.17	1.64	2.24
0	1.95	3.68	2.74	2.30	2.33	2.34	1.53	1.96	2.75
1	1.72	2.66	2.05	1.61	1.60	2.17	1.42	0.81	3.53
2	1.62	2.00	1.62	2.29	2.04	1.95	1.59	0.72	1.94
3	1.29	1.93	1.47	1.21	1.25	1.35	1.82	0.70	1.73
4	2.47	3.77	4.51	5.37	4.35	4.06	4.02	3.83	3.85
5	2.70	3.25	3.32	4.73	4.45	3.99	3.20	2.84	3.45
6	2.90	3.15	3.09	4.56	4.05	3.46	3.14	4.21	3.23
7	2.51	2.61	2.94	4.61	4.05	3.02	3.15	4.23	3.74

Figure G1. Overall project diel distribution for Block 1. The Dalles Dam, 1985.

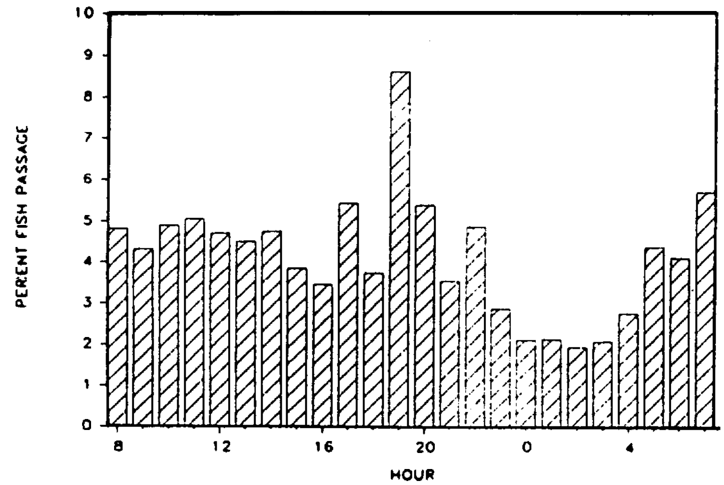


Figure G2. Hourly project river flow for Block 1. The Dalles Dam, 1985.

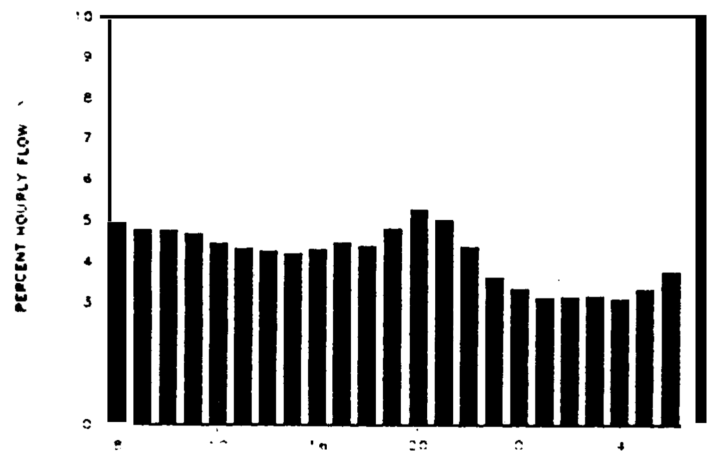
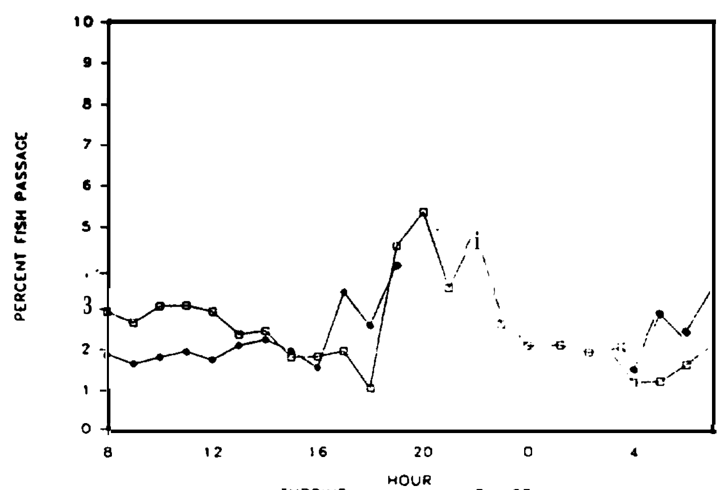


Figure G3. Diel distribution by location for Block 1. The Dalles Dam, 1985.



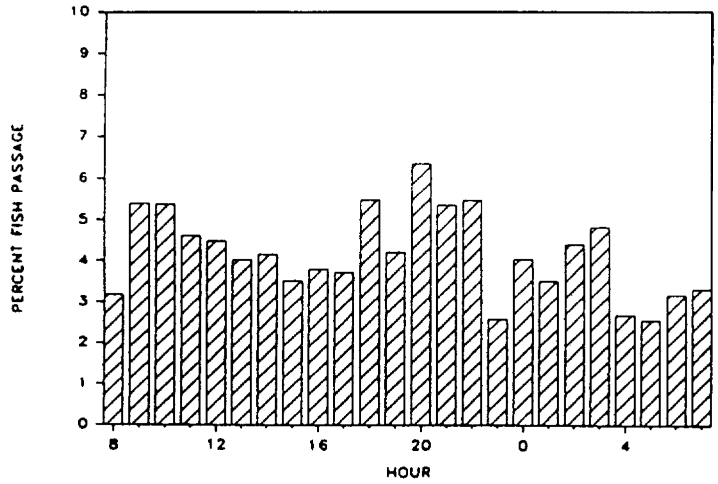


Figure G4. Overall project **diel** distribution for Block 2. The Dalles Dam, 1985.

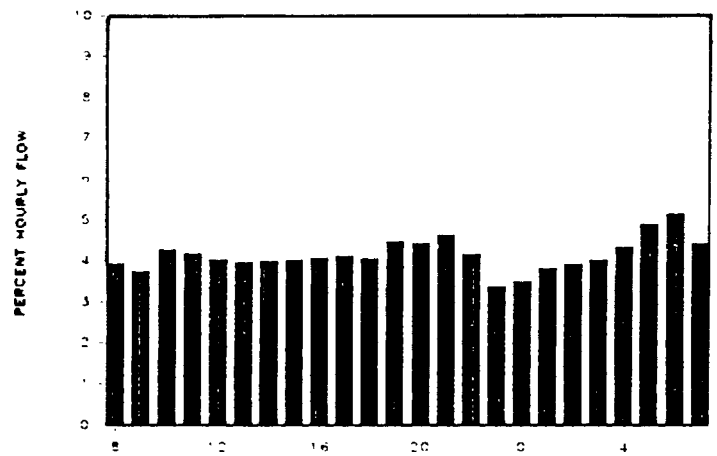


Figure **G5.** Hourly project river flow for Block 2, The Dalles Dam, 1985.

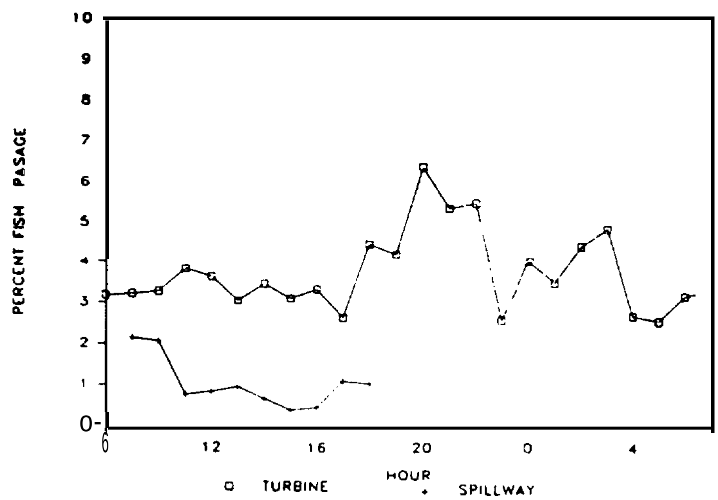


Figure G6. Diel distribution by location for Block 2. The Dalles Dam, 1985.

Figure G7. Overall project **diel** distribution for Block 3. The Dalles Dam, 1985.

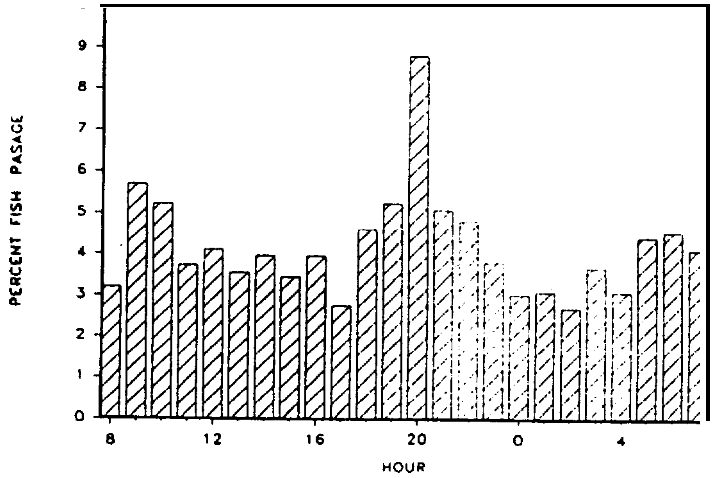


Figure G8. Hourly project river flow for Block 3. The Dalles Dam, 1985.

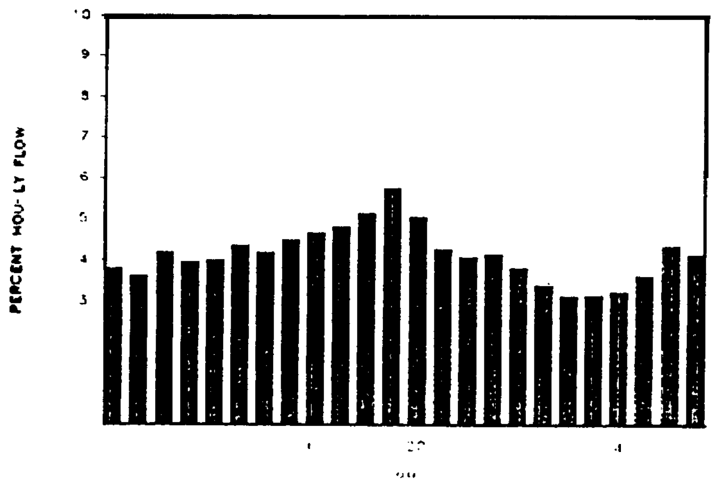
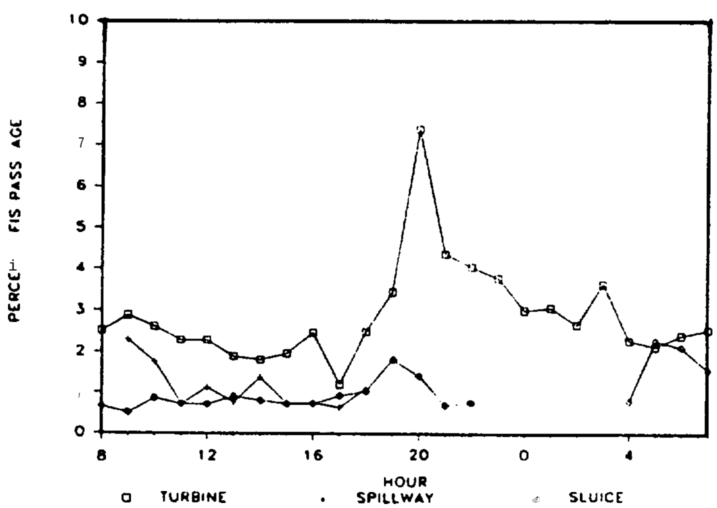


Figure **G9. Diel** distribution by location for Block 3. The Dalles Dam, 1985.



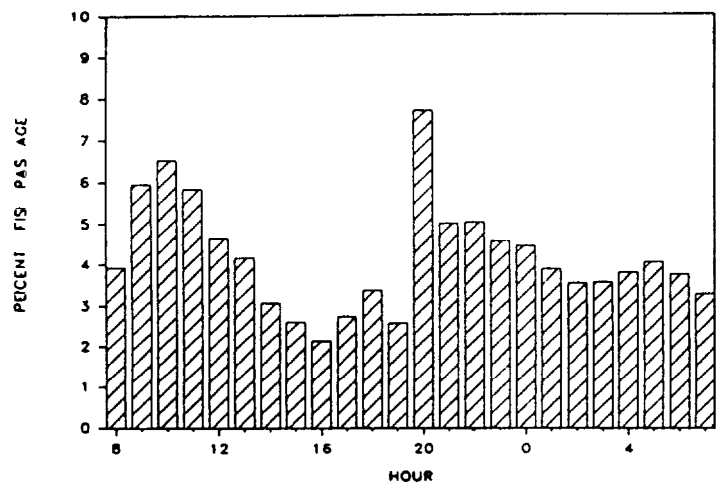


Figure G10. Overall project die1 distribution for Block 4. The Dalles Dam, 1985.

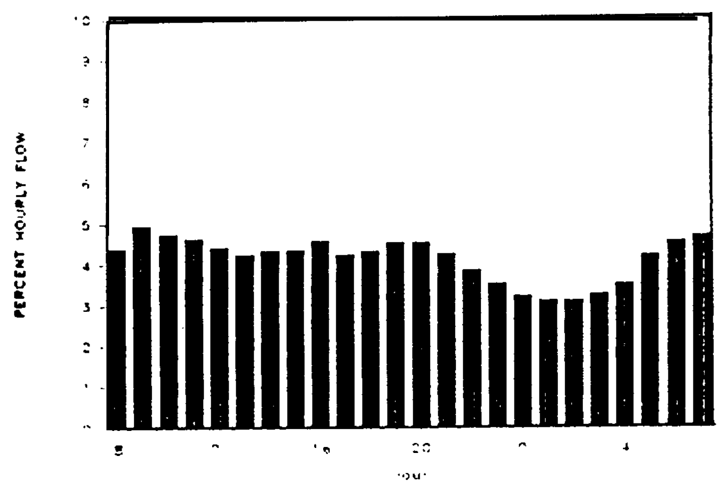


Figure G11. Hourly project river flow for Block 4. The Dalles Dam, 1985.

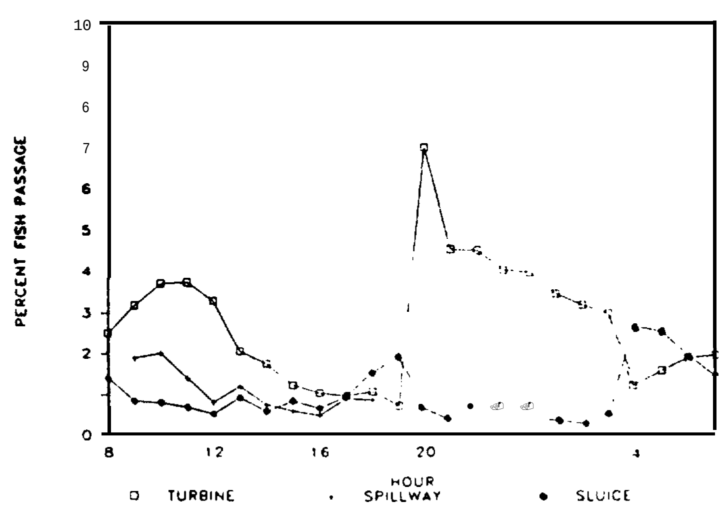


Figure G12. Die1 distribution by location for Block 4. The Dalles Dam, 1985.

Figure G13. Overall project diel distribution for Block 5. The Dalles Dam, 1985.

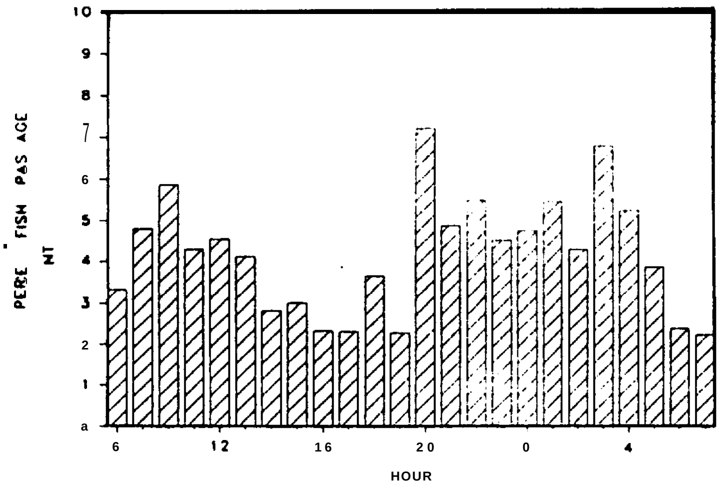


Figure G14. Hourly project river flow for Block 5. The Dalles Dam, 1985.

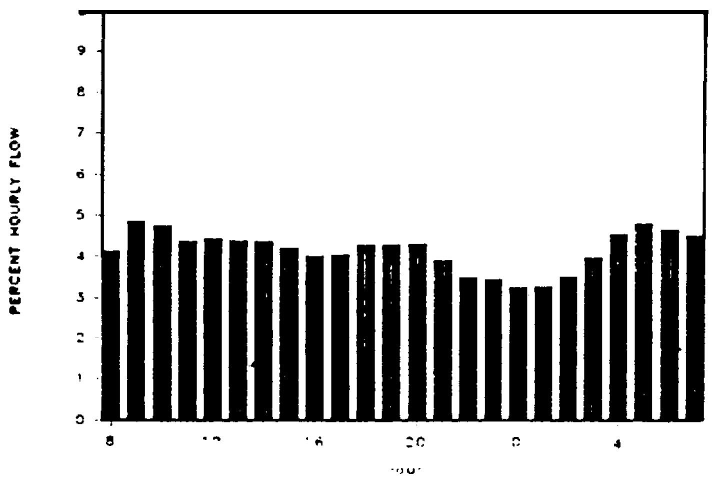


Figure G15. Diel distribution by location for Block 5. The Dalles Dam, 1985.

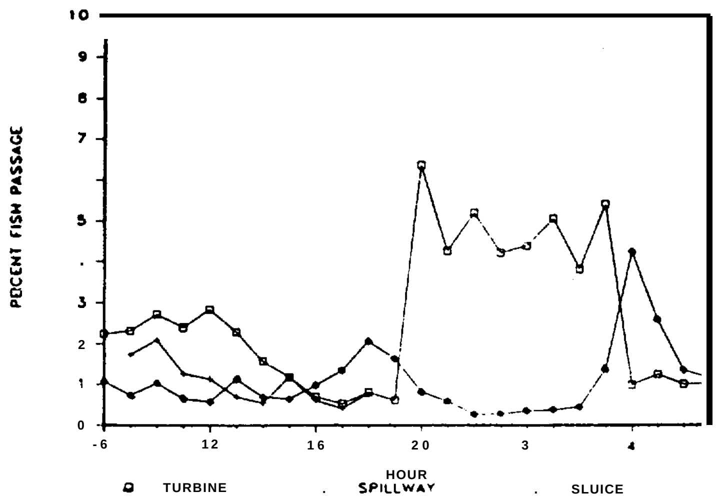


Figure G16. Overall project die1 distribution for Block 6. The Dalles Dam, 1985.

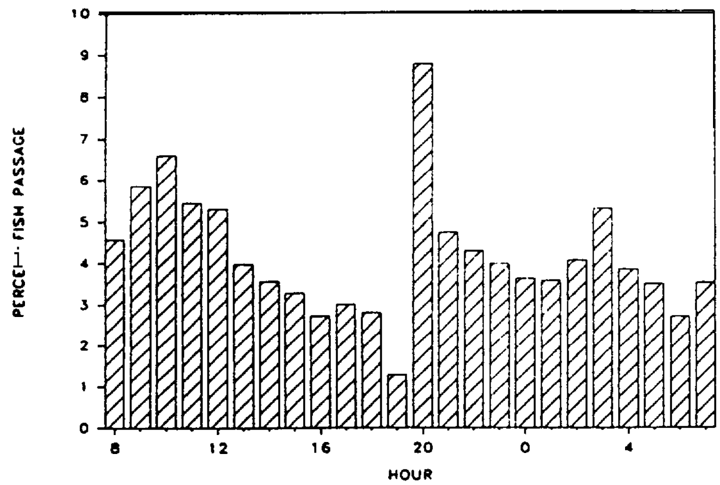


Figure G17. Hourly project river flow for Block 6. The Dalles Dam, 1985.

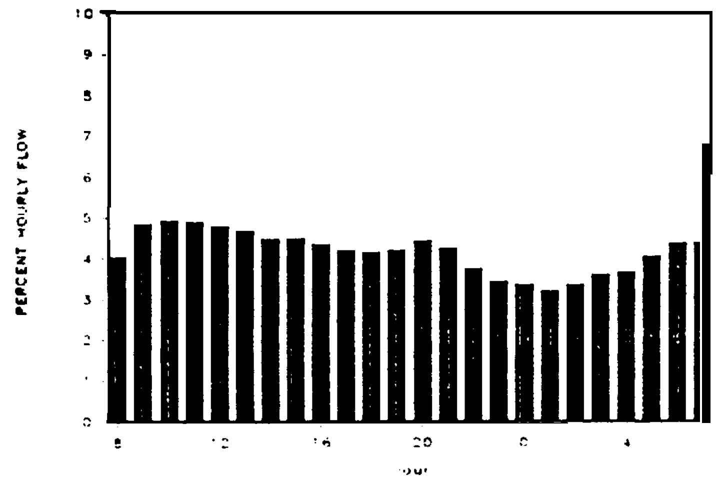


Figure G18. Die1 distribution by location for Block 6. The Dalles Dam, 1985.

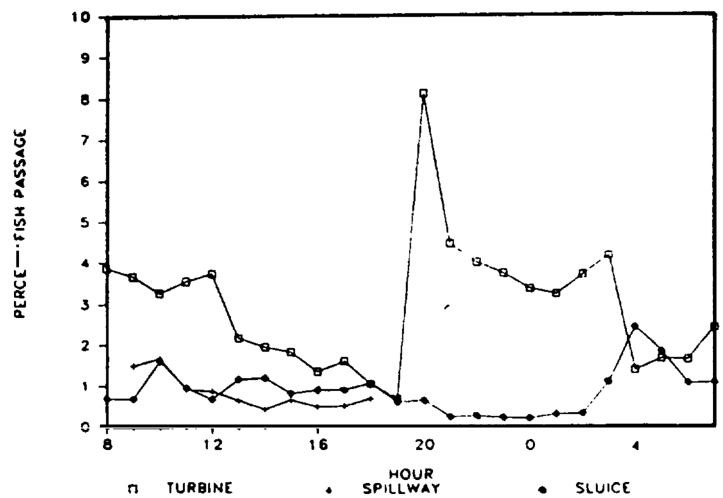


Figure G19. Overall project diel distribution for Block 7. The Dalles Dam, 1985.

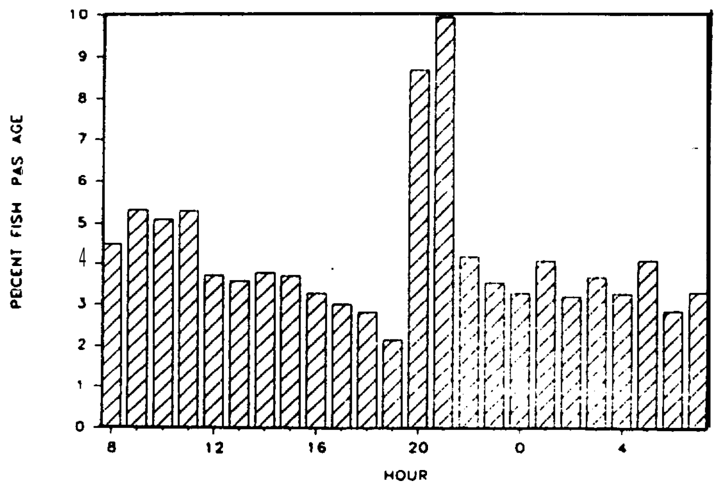


Figure G20. Hourly project river flow for Block 7. The Dalles Dam, 1985.

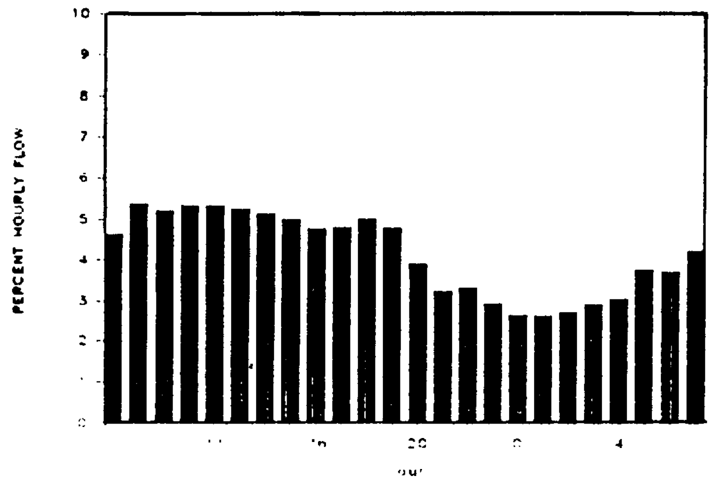


Figure G21. **Diel** distribution by location for Block 7. The Dalles Dam, 1985.

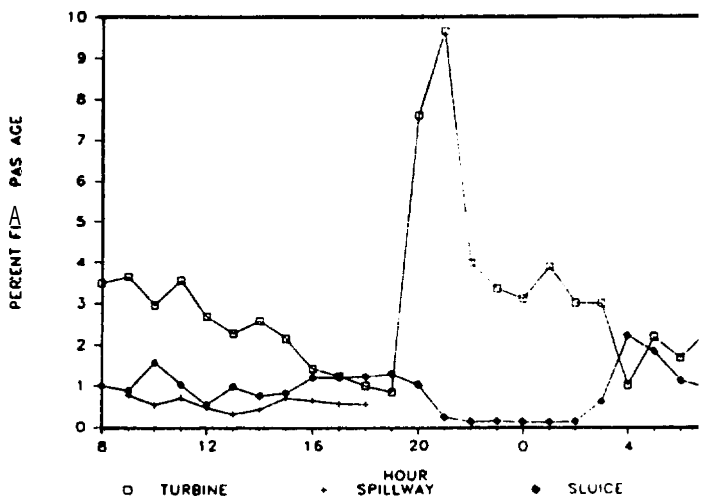


Figure G22. Overall project **diel** distribution for Block 8. The Dalles Dam, 1985.

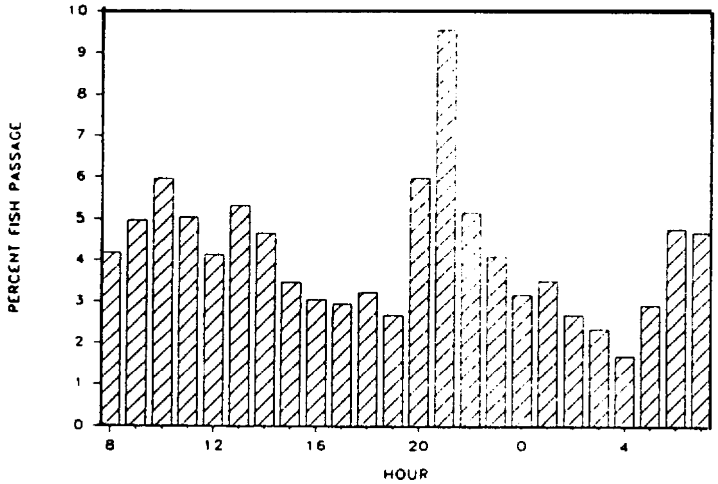


Figure 623. Hourly project river flow for Block 8. The Dalles Dam, 1985.

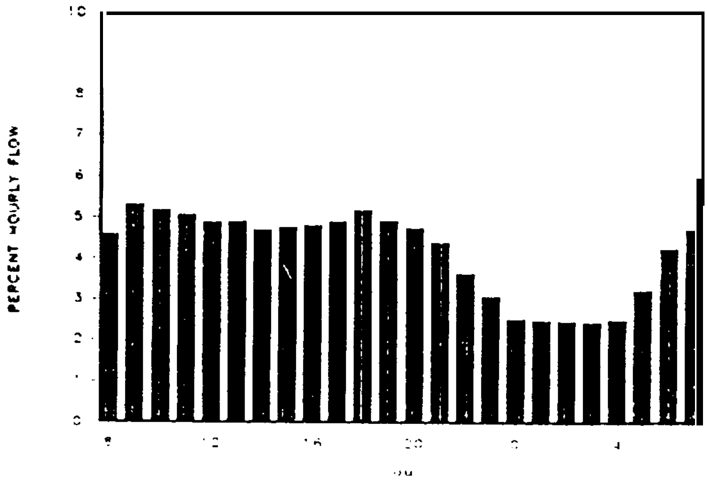


Figure **G24. Diel** distribution by location for Block 8. The Dalles Dam, 1985.

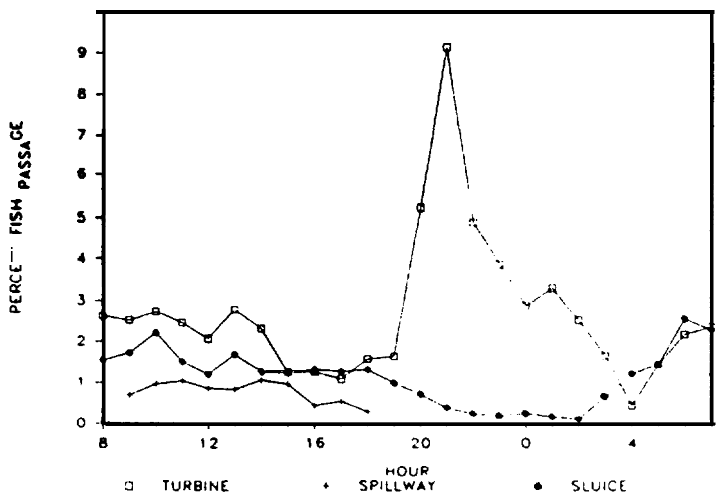


Figure G25. Overall project diel distribution for Block 9. The Dalles Dam, 1985.

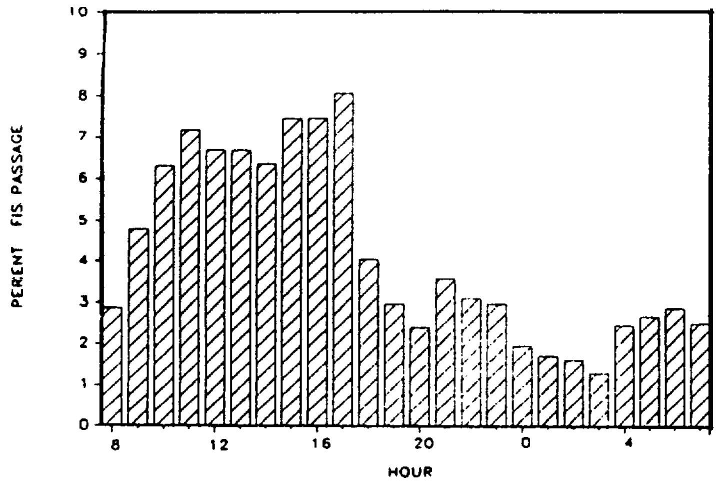


Figure G26. Hourly project river flow for Block 9. The Dalles Dam, 1985.

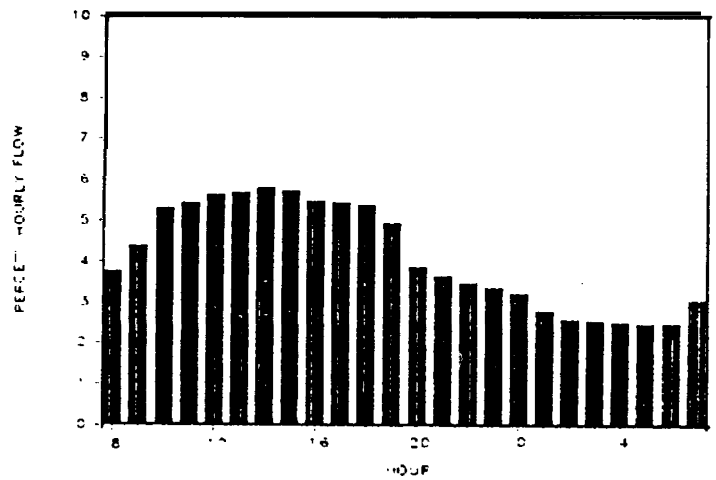


Figure G27. Diel distribution by location for Block 9. The Dalles Dam, 1985.

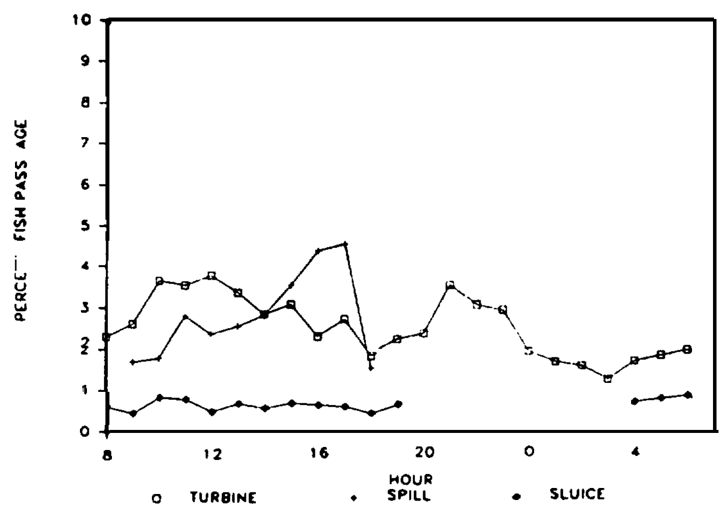


Figure G28. Overall project die1 distribution for Block 10. The Dalles Dam, 1985.

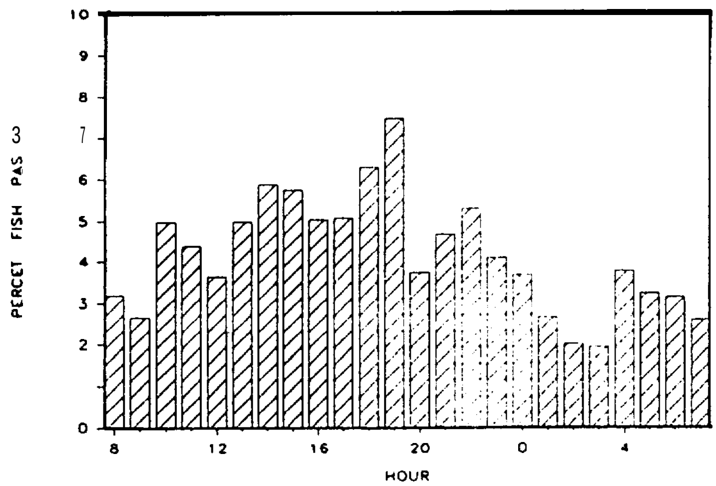


Figure G29. Hourly project river flow for Block 10. The Dalles Dam, 1985.

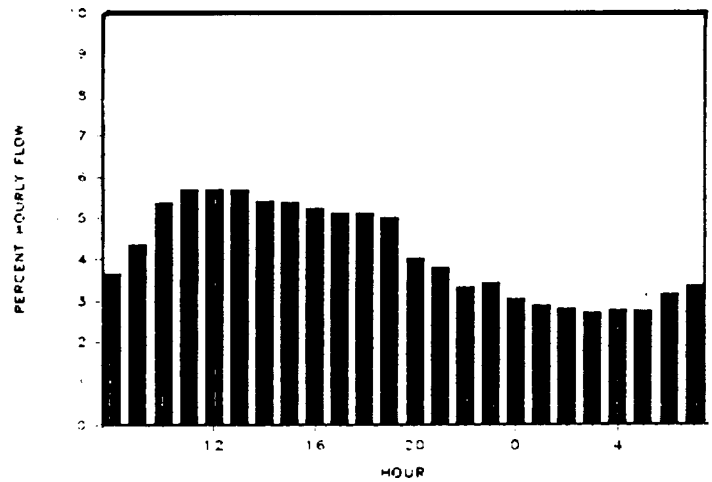


Figure G30. Die1 distribution by location for Block 10. The Dalles Dam, 1985.

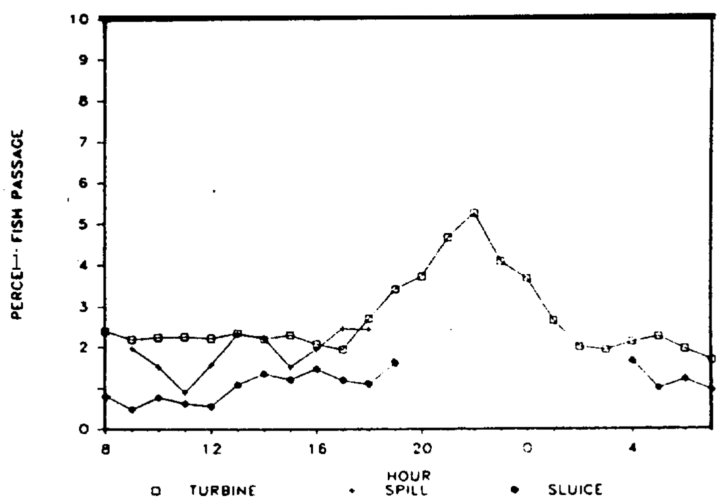


Figure G31. Overall project **diel** distribution for Block 11. The Dalles Dam, 1985.

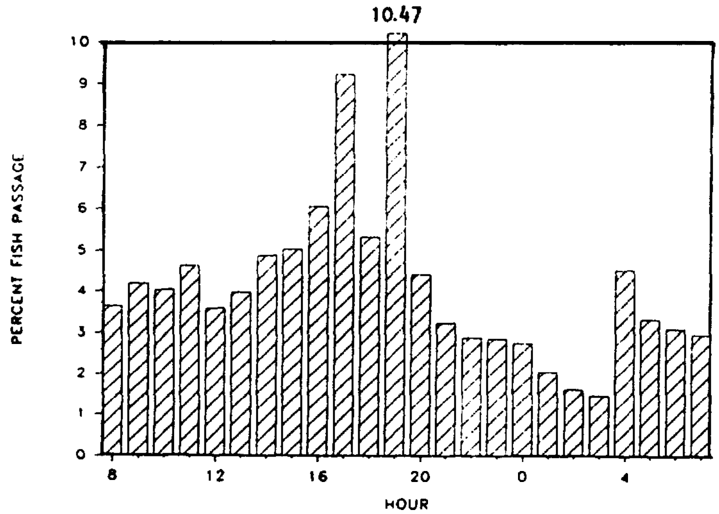


Figure G32. Hourly project river flow for Block 11. **The** Dalles Dam, 1985.

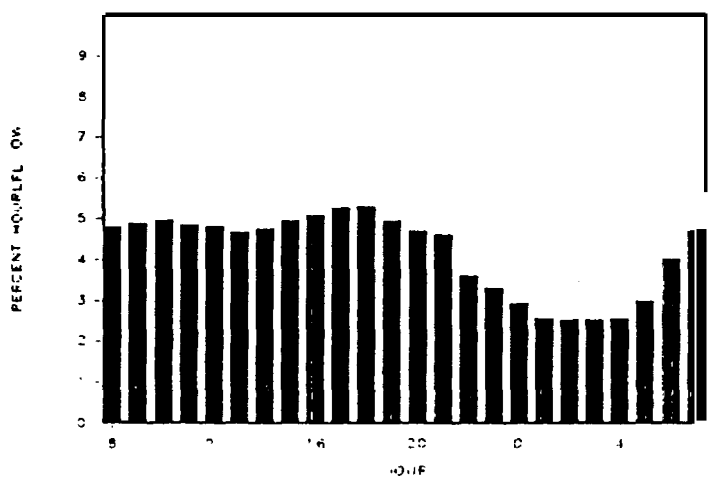


Figure **G33. Diel** distribution by location for Block 11. The Dalles Dam, 1985.

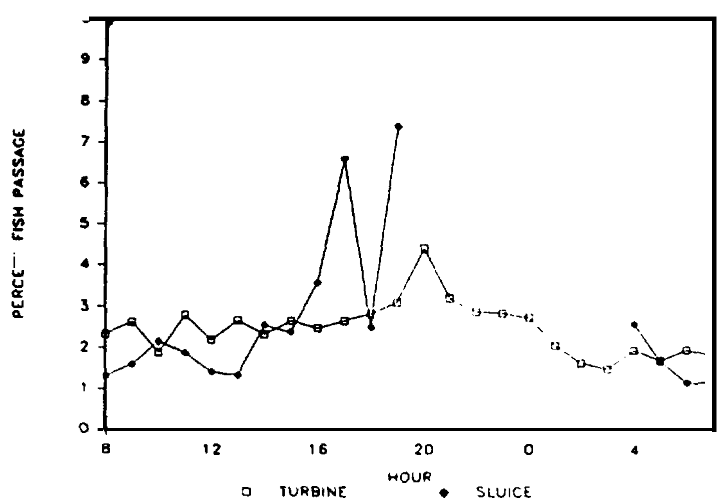


Figure G34. Overall project diel distribution for Block 12. The Dalles Dam, 1985.

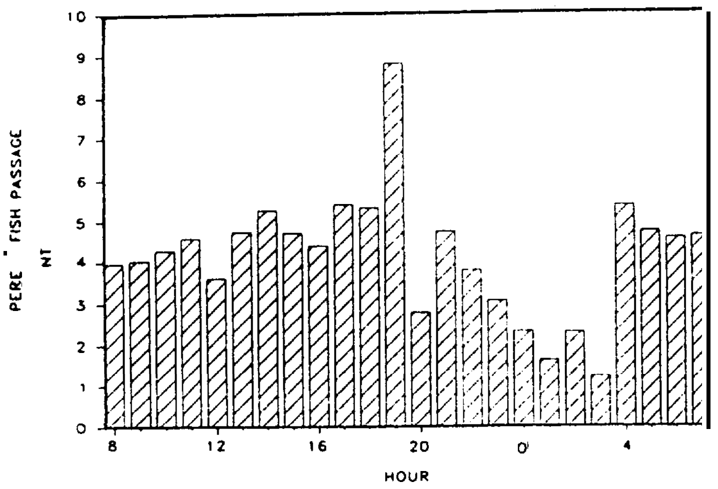


Figure G35. Hourly project river flow for Block 12. The Dalles Dam, 1985.

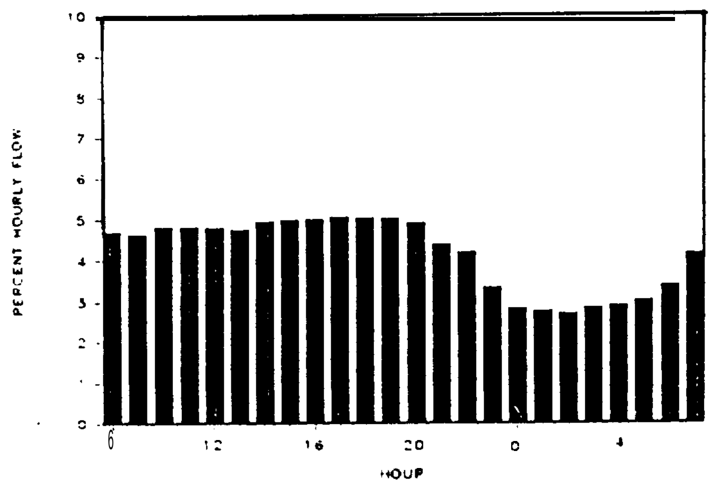


Figure G36. Diel distribution by location for Block 12. The Dalles Dam, 1985.

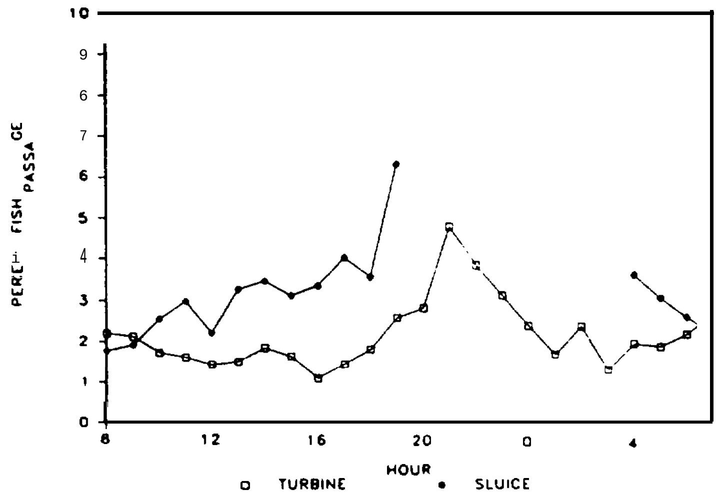


Figure 637. Overall project **diel** distribution for Block 13. The Dalles Dam, 1985.

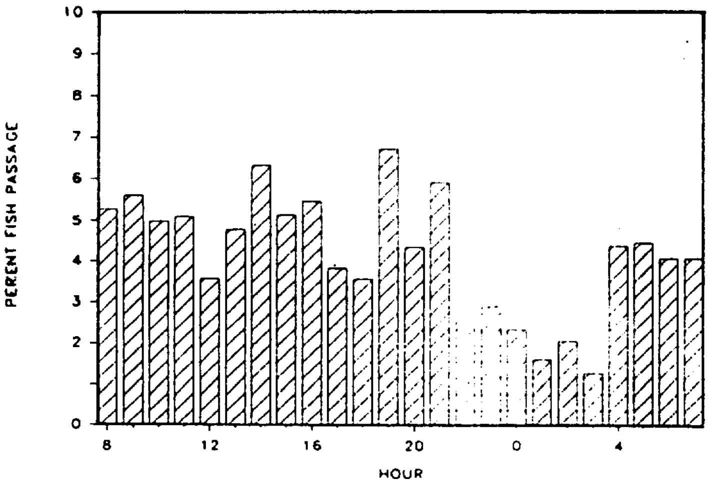


Figure G38. Hourly project river flow for Block 13. The Dalles Dam, 1985.

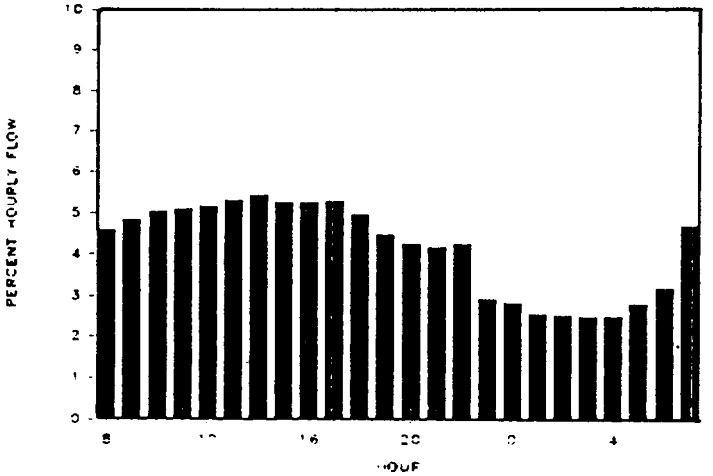
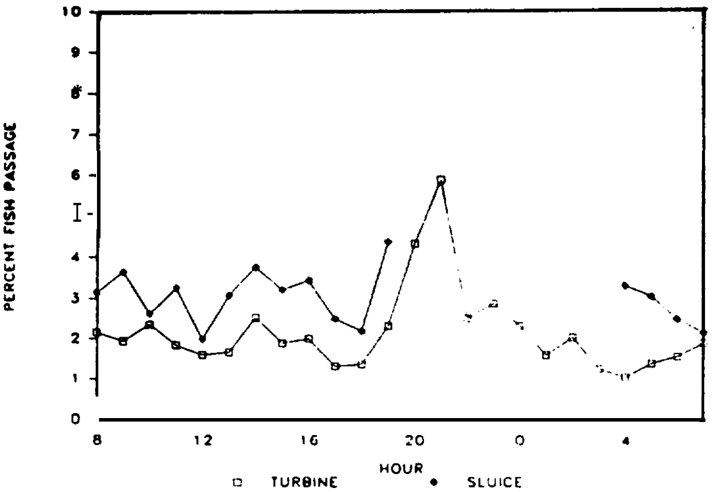


Figure G39. **Diel** distribution by location for Block 13. The Dalles Dam, 1985.



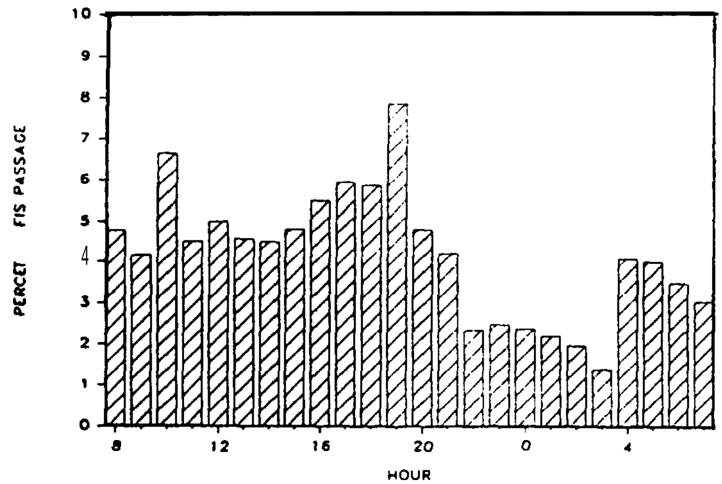


Figure 640. Overall project **diel** distribution for Block 14. The Dalles Dam, 1985.

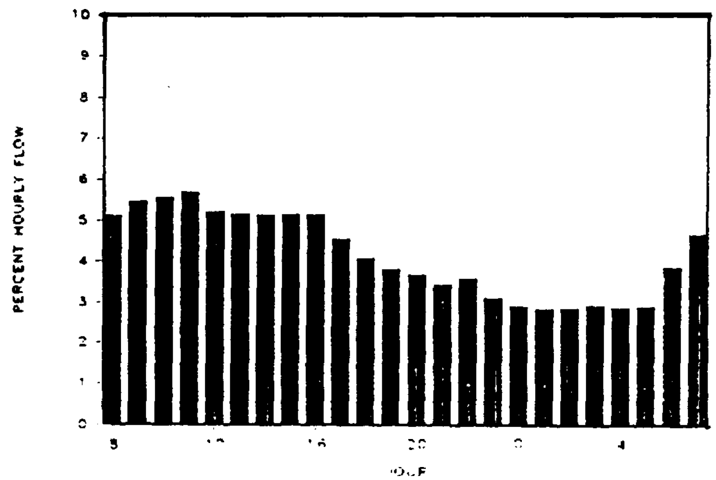


Figure **G41.** Hourly project river flow for Block 14. The Dalles Dam, 1985.

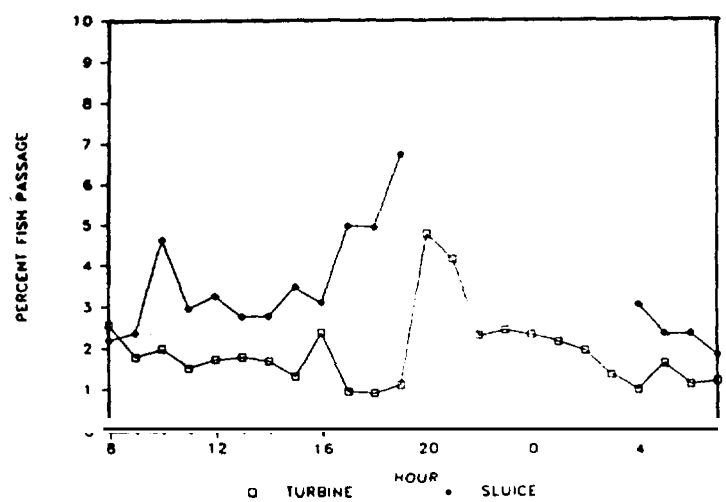


Figure G42. **Diel** distribution by location for Block 14. The Dalles Dam, 1985.

Figure G43. Overall project **diel** distribution for Block 15. The Dalles Dam, 1985.

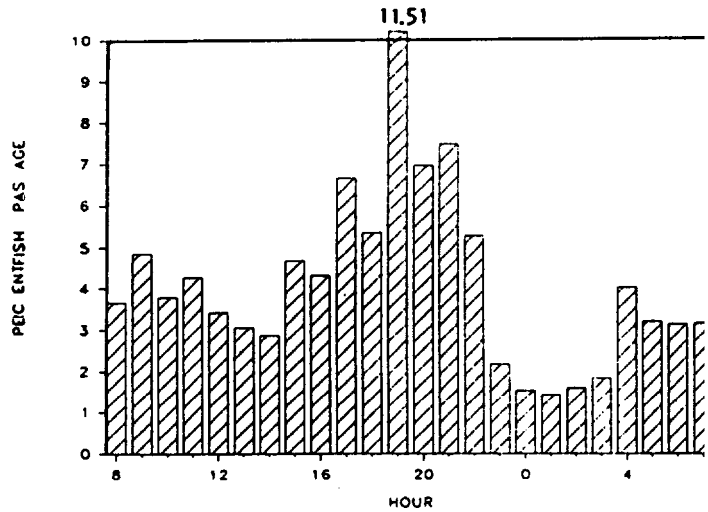


Figure 644. **Hourly** project river flow for Block 15. The Dalles Dam, 1985.

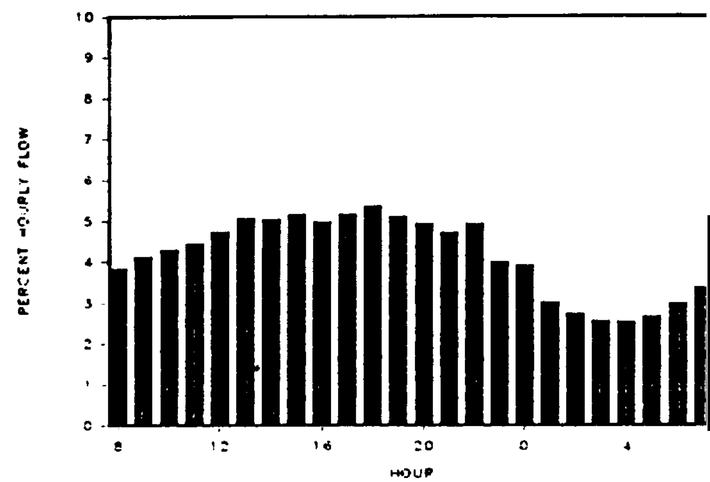


Figure **G45. Diel** distribution by location for Block 15. The Dalles Dam, 1985.

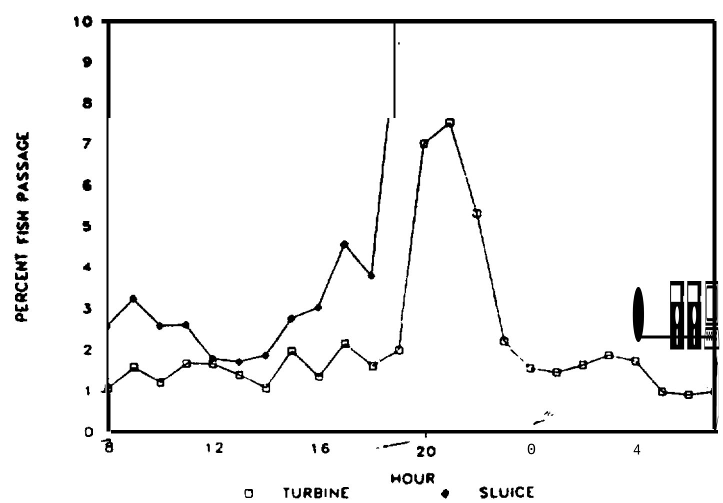


Figure G46. Overall project diel distribution for Block 16. The Dalles Dam, 1985.

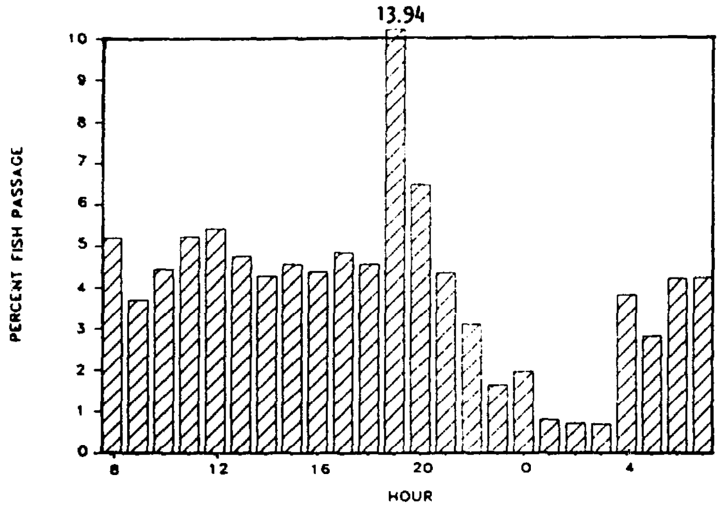


Figure G47. Hourly project river flow for Block 16. The Dalles Dam, 1985.

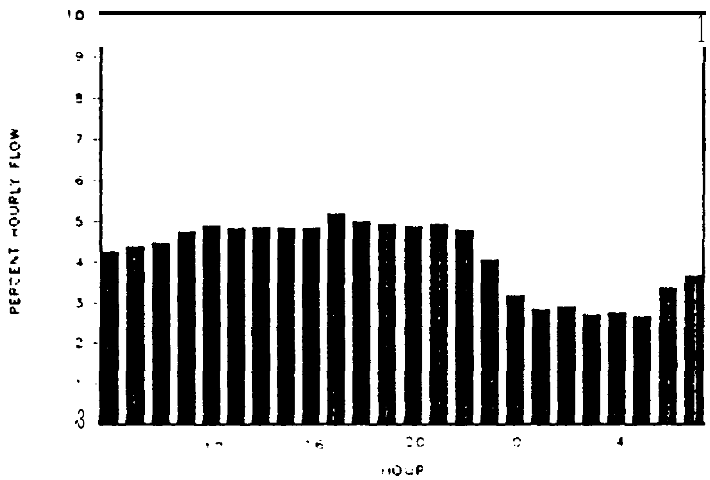


Figure G48. Diel distribution by location for Block 16. The Dalles Dam, 1985.

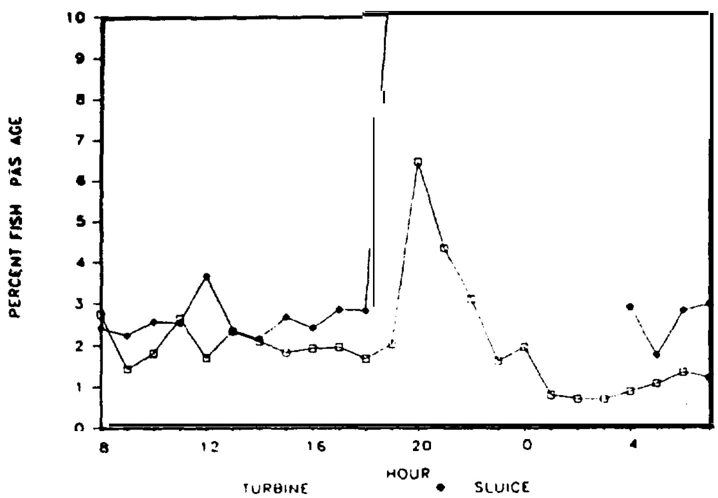


Figure G49. Overall project **diel** distribution for Block 17. The Dalles Dam, 1985.

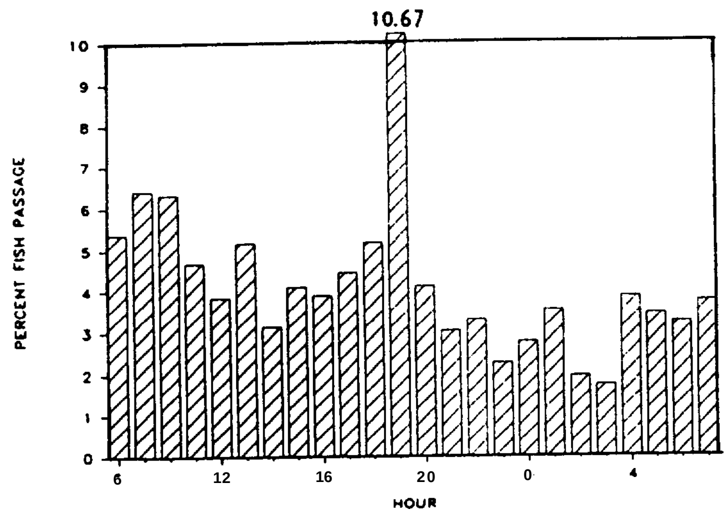


Figure G50. **Hourly** project river flow for Block 17. The Dalles Dam, 1985.

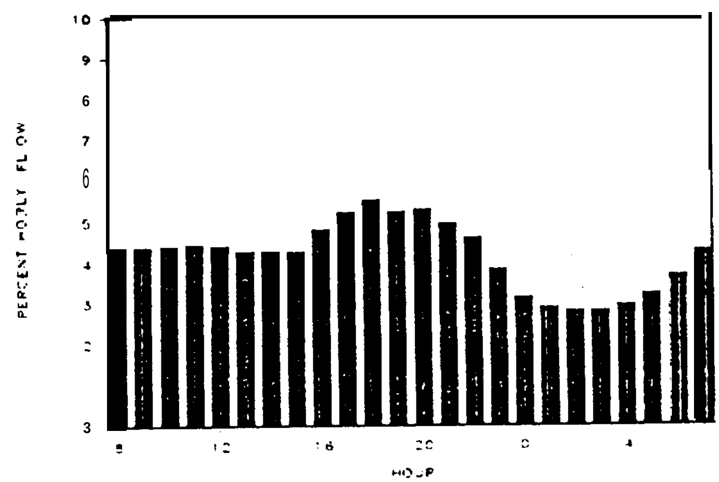
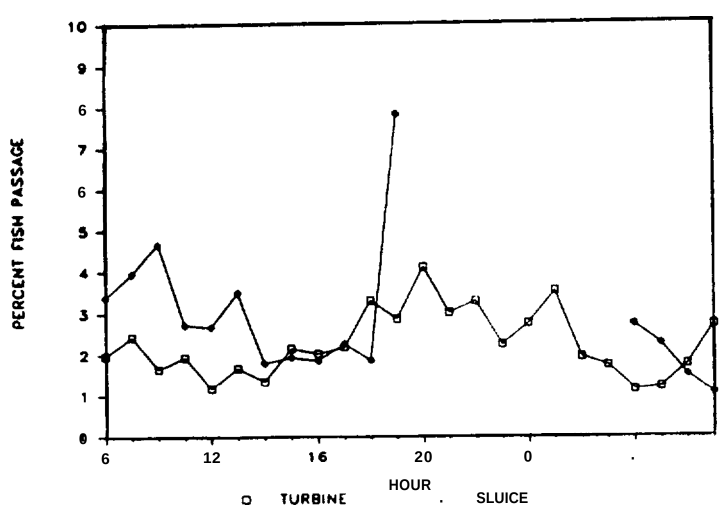


Figure G51. **Diel** distribution by location for Block 17. The Dalles Dam, 1985.



APPENDIX H: Horizontal Distributions by Time Block

Horizontal distributions across the powerhouse are given for Blocks 1-17 in Tables H1 and H2 for the spring and summer studies, respectively. Tables H3 (spring) and H4 (summer) present the horizontal distributions across the spillway for Blocks 2-11 (periods when spill occurred). The individual horizontal distributions for each block are presented in Figures H1 - H17 (powerhouse) and in Figures H18 - H26 (spillway).

Table H1. Relative percent horizontal distributions for spring at the powerhouse. The Dalles Dam, 1985.

	Turbine Unit					
Block	T1	T3	T9	T13	T16	T22
1	22.61	26.99	12.62	12.54	17.49	7.76
2	23.12	24.08	13.25	15.32	16.89	7.35
3	26.21	24.61	13.20	13.25	17.41	5.32
4	14.57	23.88	12.60	19.17	24.97	4.82
5	17.30	24.20	12.21	18.47	21.23	6.58
6	15.33	30.27	12.09	15.56	19.68	7.07
7	16.59	26.19	13.04	17.76	20.34	6.08
8	18.28	29.49	10.49	14.02	19.03	8.68
Season	19.25	26.21	12.44	15.76	19.63	6.71

Table H2. Relative percent horizontal distributions for summer at the powerhouse. The Dalles Dam, 1985.

	Turbine Unit					
Block	T1	T3	T9	T13	T16	T22
9	15.61	20.63	12.20	15.22	16.50	19.85
10	13.38	16.05	12.12	15.50	19.85	23.10
11	10.05	18.01	13.83	16.07	21.53	20.50
12	10.35	20.67	12.90	16.55	19.24	20.28
13	15.10	22.53	11.20	14.02	17.51	19.64
14	17.29	22.43	9.15	19.76	14.15	17.22
15	14.25	20.39	11.18	17.82	20.07	16.28
16	10.59	23.78	14.92	19.14	13.41	18.16
17	11.06	22.67	10.35	9.79	17.77	28.36
Season	13.08	20.80	11.98	15.99	17.78	20.38

Table H3. Relative percent horizontal distributions for spring at the spillway. The Dalles Dam, 1985.

Block	Spill Gate S1	s2	s3	s7	s12	s17	s21	S23
2	26.06	4.81	15.38	10.84	6.33	10.99	16.98	8.62
3	16.81	9.12.	14.49	16.56	11.26	11.10	10.27	10.39
4	10.73	11.88	5.61	14.38	16.45	17.80	10.35	12.79
5	13.90	7.05	8.88	17.94	15.98	17.93	8.64	9.68
6	9.15	5.45	5.39	16.16	21.18	21.39	10.71	10.57
7	14.88	11.23	11.94	17.80	15.63	11.06	7.64	9.82
8	15.42	8.49	6.69	18.74	12.10	11.05	14.42	13.08
Season	15.28	8.29	9.77	16.06	14.13	14.47	11.29	10.71

Table H4. Relative percent horizontal distributions for summer at the spillway. The Dalles Dam, 1985.

Block	spill Gate S1	S2	s3	s7	s12	s17	s21	S23
9	13.68	9.90	14.17	8.15	16.36	8.56	12.83	16.36
10	10.85	12.38	11.87	9.18	No Flow	11.36	18.83	25.53

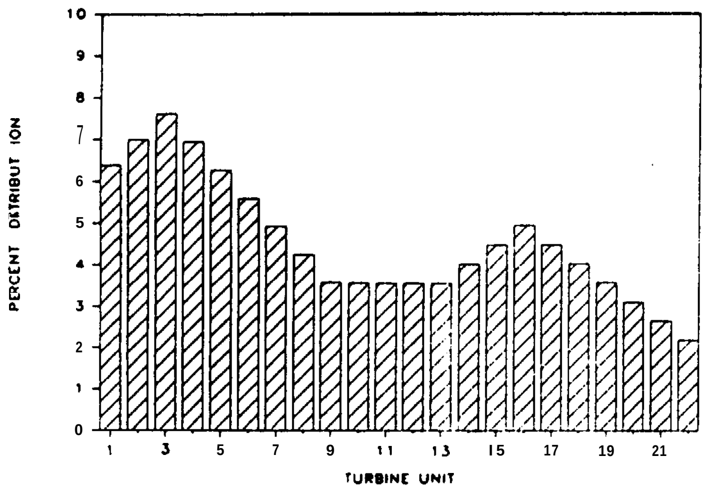


Figure H1. Horizontal distribution across the powerhouse for Block 1. The Dalles Dam, 1985.

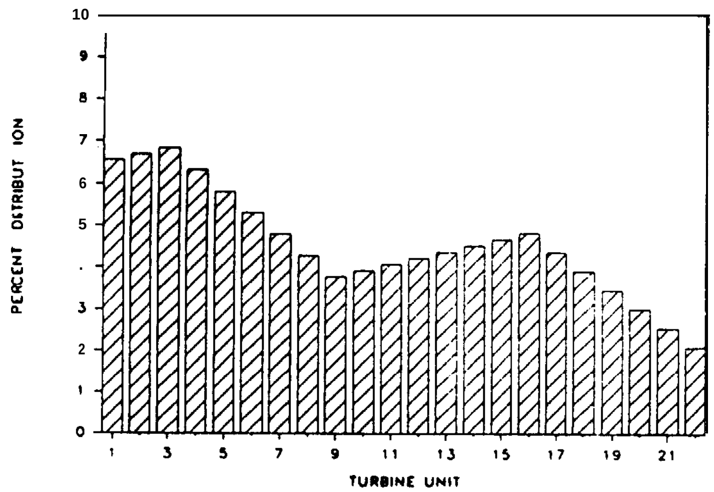


Figure H2. Horizontal distribution across the powerhouse for Block 2. The Dalles Dam, 1985.

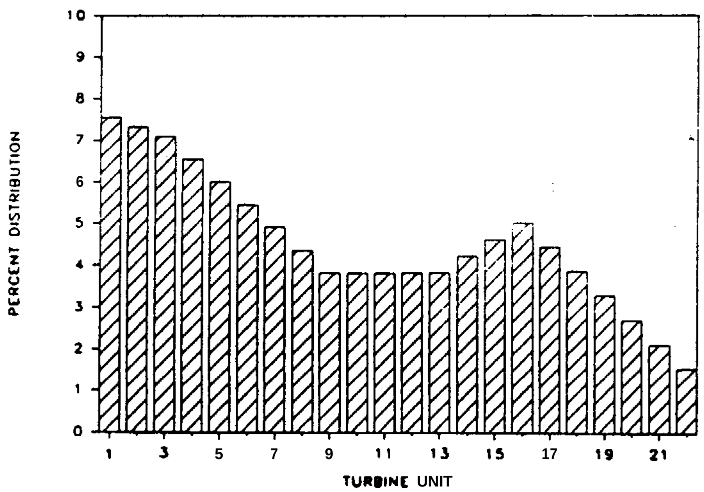


Figure H3. Horizontal distribution across the powerhouse for Block 3. The Dalles Dam, 1985.

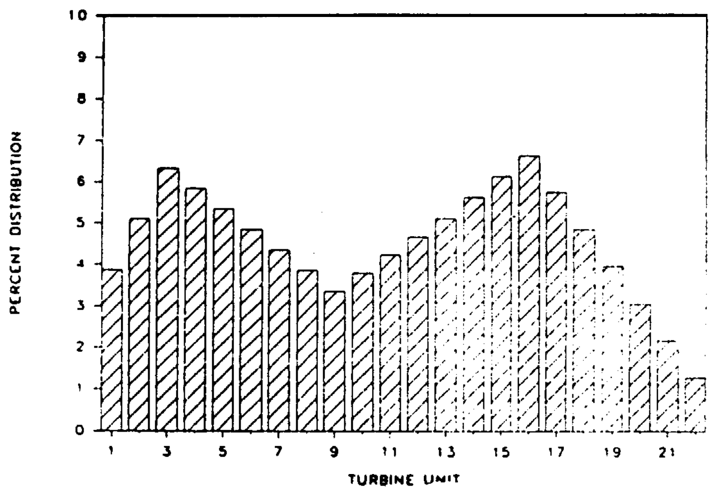


Figure H4. Horizontal distribution across the powerhouse for Block 4. The Dalles Dam, 1985.

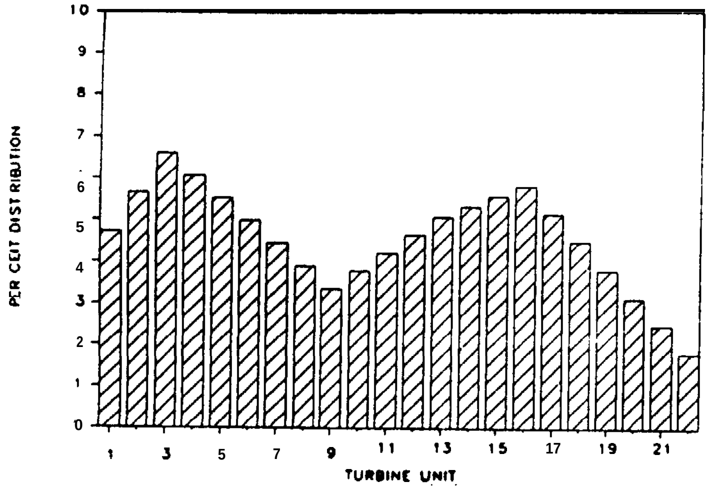


Figure H5. Horizontal distribution across the powerhouse for Block 5. The Dalles Dam, 1985.

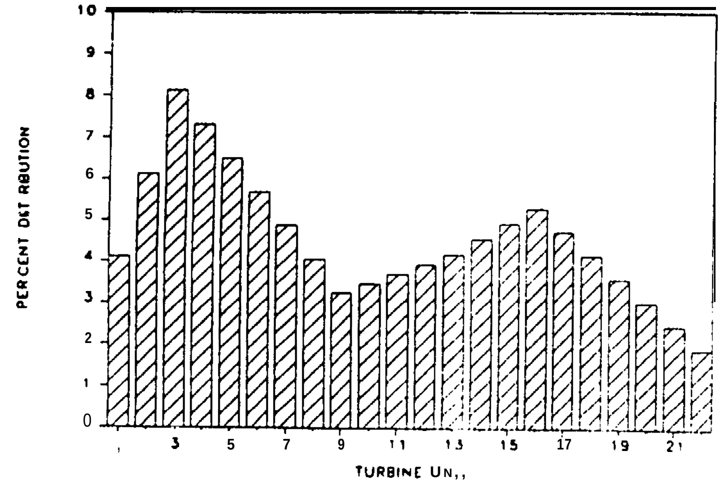


Figure H6. Horizontal distribution across the powerhouse for Block 6. The Dalles Dam, 1985.

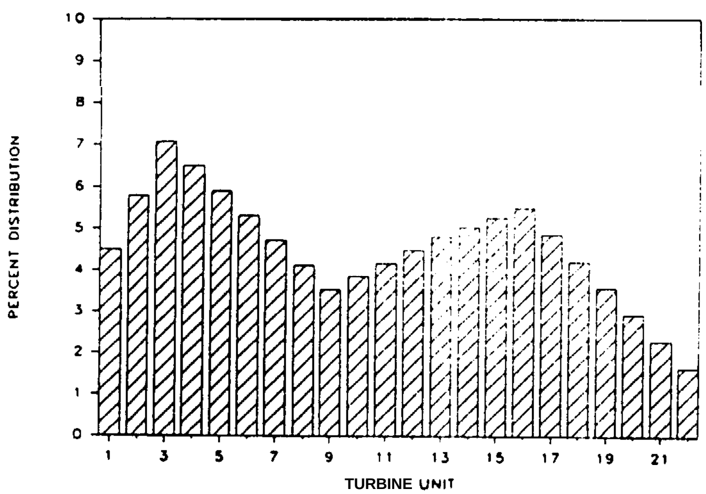


Figure H7. Horizontal distribution across the powerhouse for Block 7. The Dalles Dam, 1985.

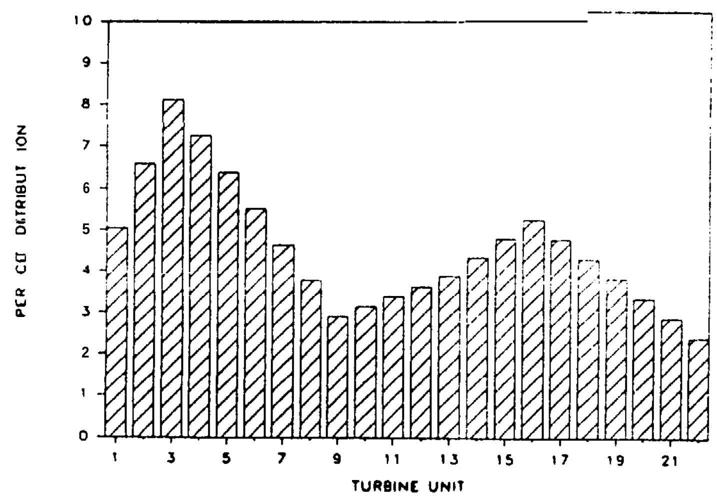


Figure H8. Horizontal distribution across the powerhouse for Block 8. The Dalles Dam, 1985.

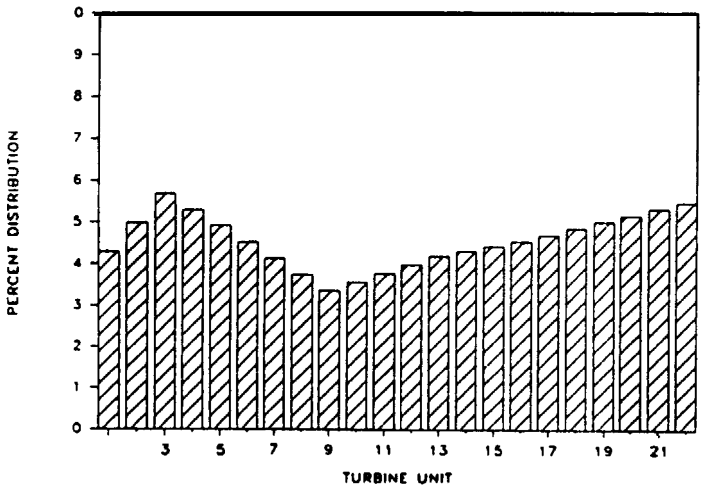


Figure H9. Horizontal distribution across the powerhouse for Block 9. The Dalles Dam, 1985.

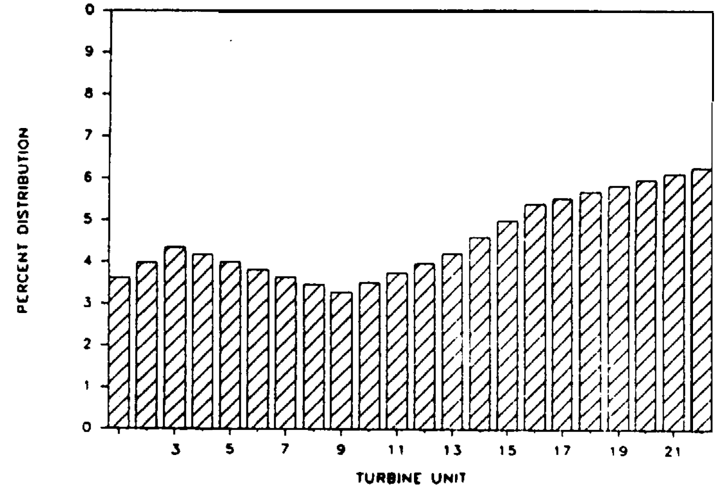


Figure H10. Horizontal distribution across the powerhouse for Block 10. The Dalles Dam, 1985.

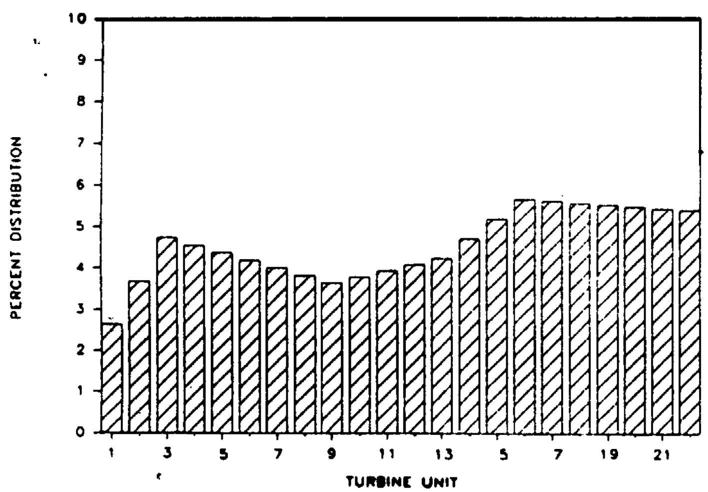


Figure H11. Horizontal distribution across the powerhouse for Block 11. The Dalles Dam, 1985.

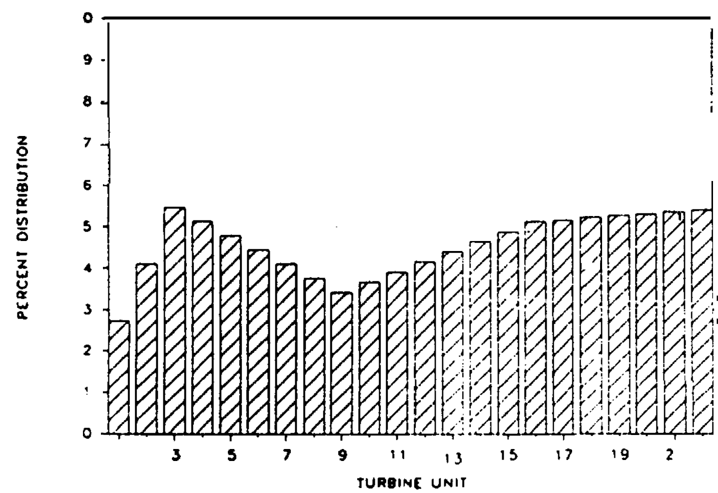


Figure H12. Horizontal distribution across the powerhouse for Block 12. The Dalles Dam, 1985.

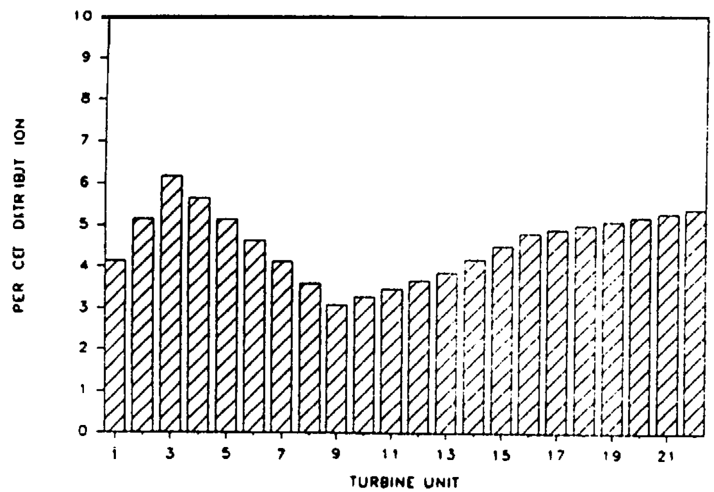


Figure H13. Horizontal distribution across the powerhouse for Block 13. The Dalles Dam, 1985.

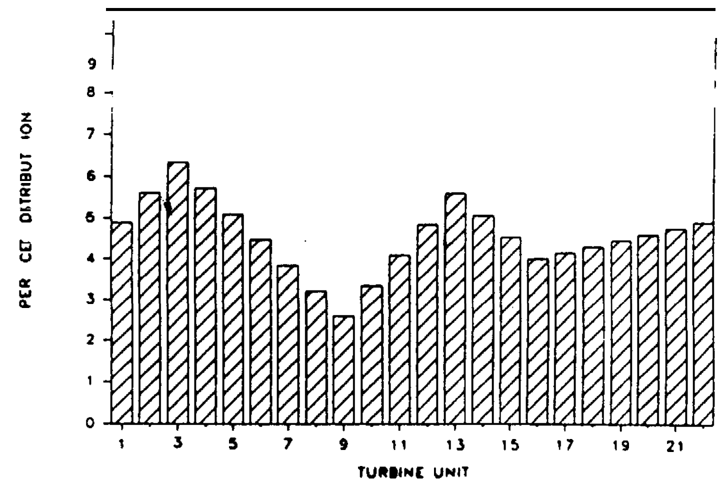


Figure H14. Horizontal distribution across the powerhouse for Block 14. The Dalles Dam, 1985.

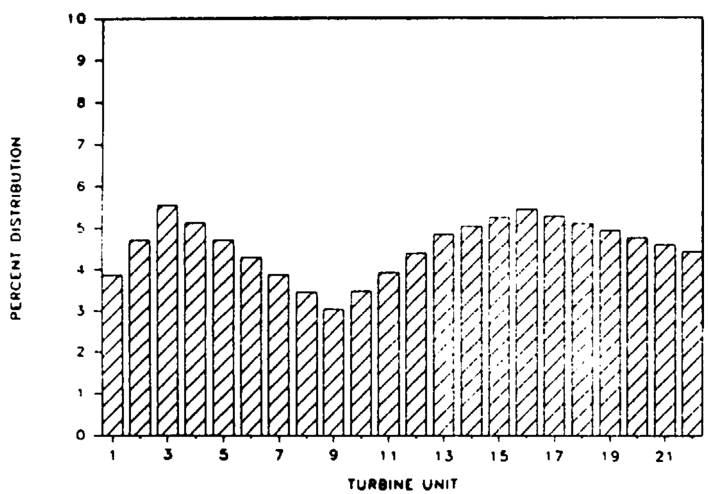


Figure H15. Horizontal distribution across the powerhouse for Block 15. The Dalles Dam, 1985.

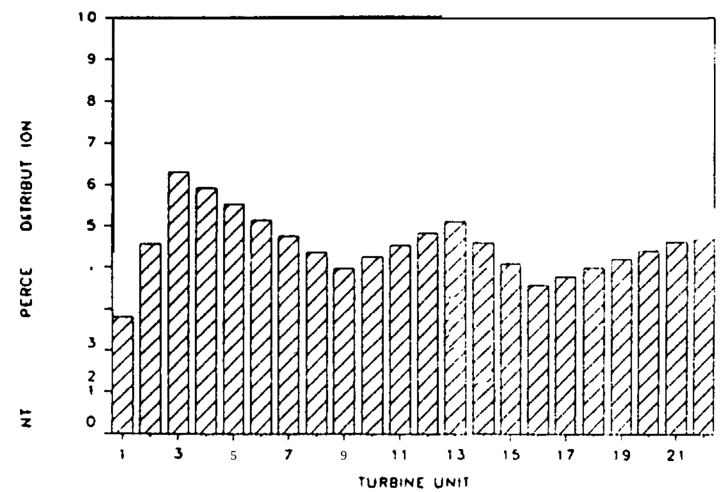


Figure H16. Horizontal distribution across the powerhouse for Block 16. The Dalles Dam, 1985.

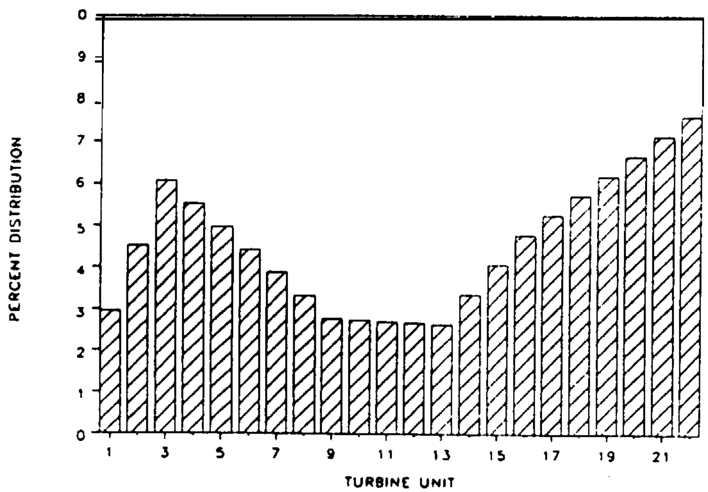


Figure H17. Horizontal distribution across the powerhouse for Block 17. The Dalles Dam, 1985.

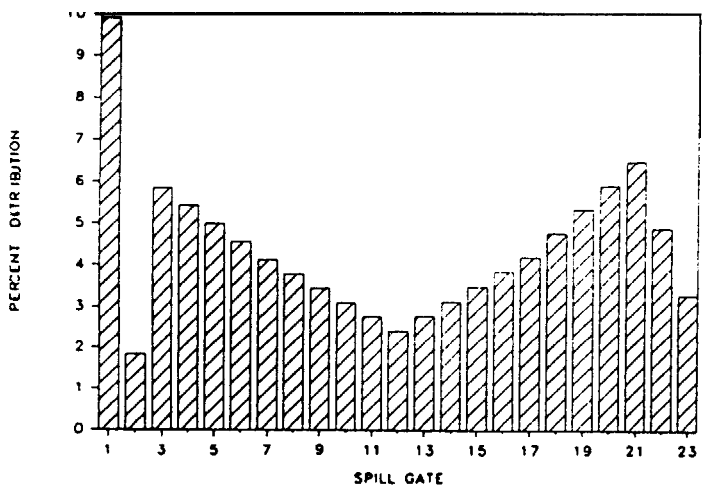


Figure H18. Horizontal distribution across the spillway for Block 2. The Dalles Dam, 1985.

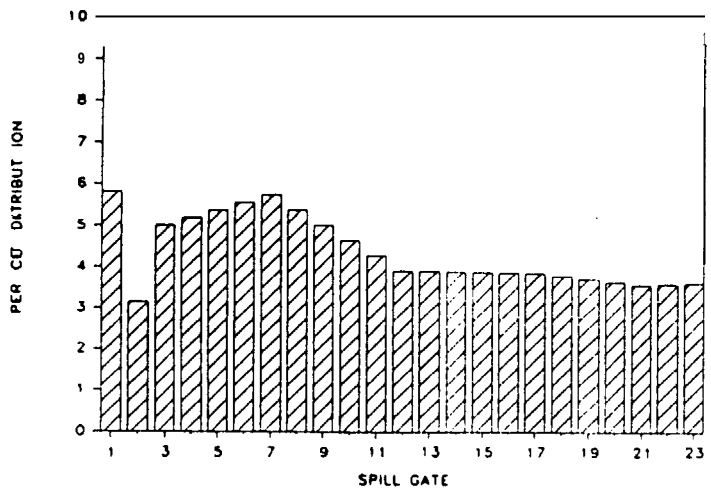


Figure H19. Horizontal distribution across the spillway for Block 3. The Dalles Dam, 1985.

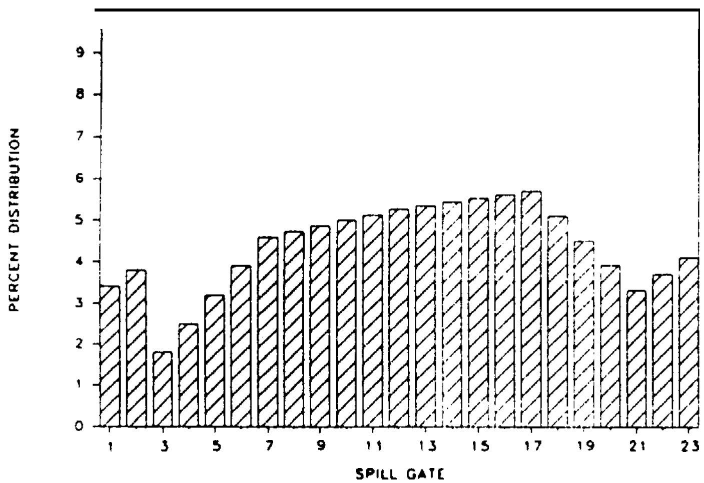


Figure H20. Horizontal distribution across the spillway for Block 4. The Dalles Dam, 1985.

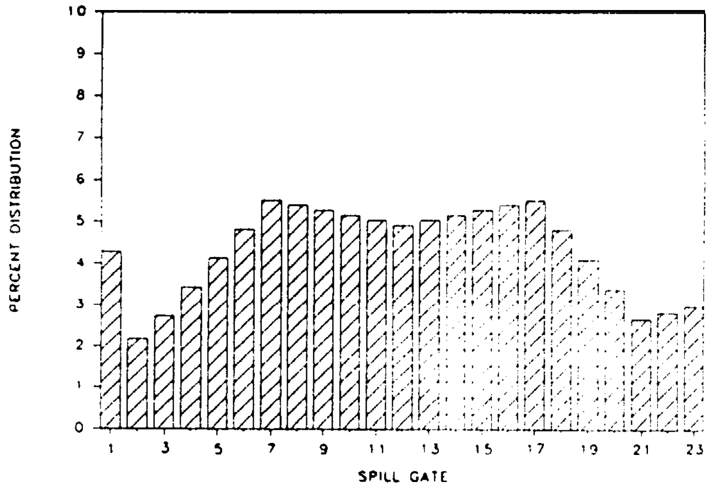


Figure H21. Horizontal distribution across the spillway for Block 5. The Dalles Dam, 1985.

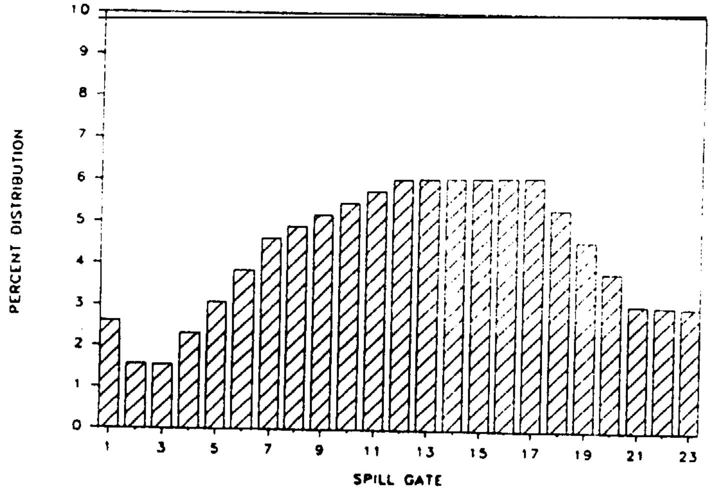


Figure H22. Horizontal distribution across the spillway for Block 6. The Dalles Dam, 1985.

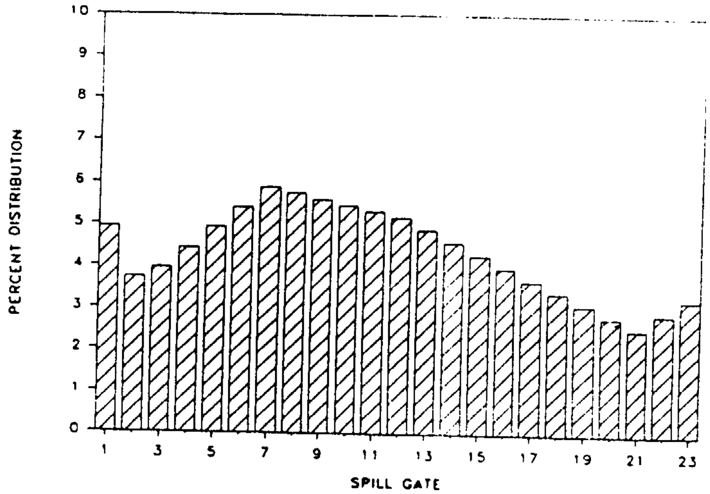


Figure H23. Horizontal distribution across the spillway for Block 7. The Dalles Dam, 1985.

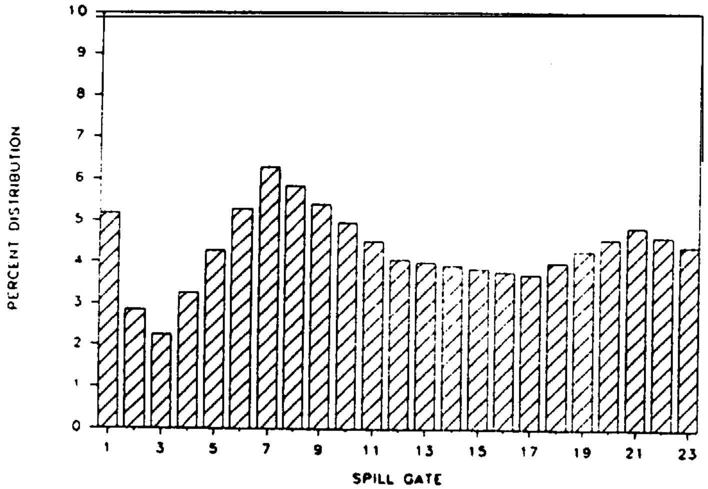


Figure H24. Horizontal distribution across the spillway for Block 8. The Dalles Dam, 1985.

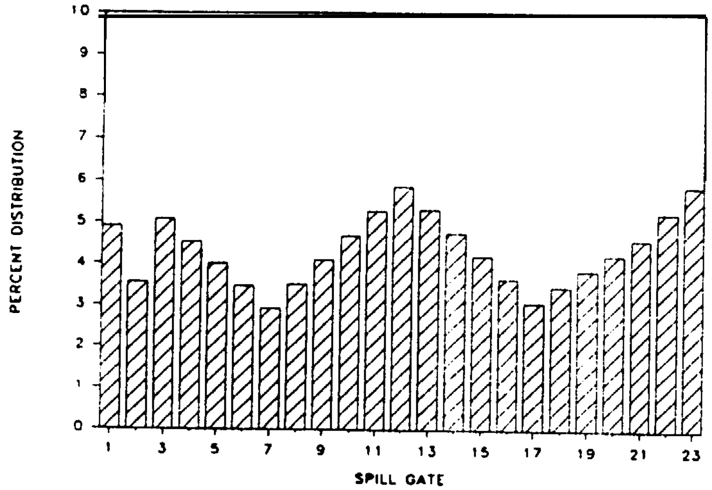


Figure H25. Horizontal distribution across the spillway for Block 9. The Dalles Dam, 1985.

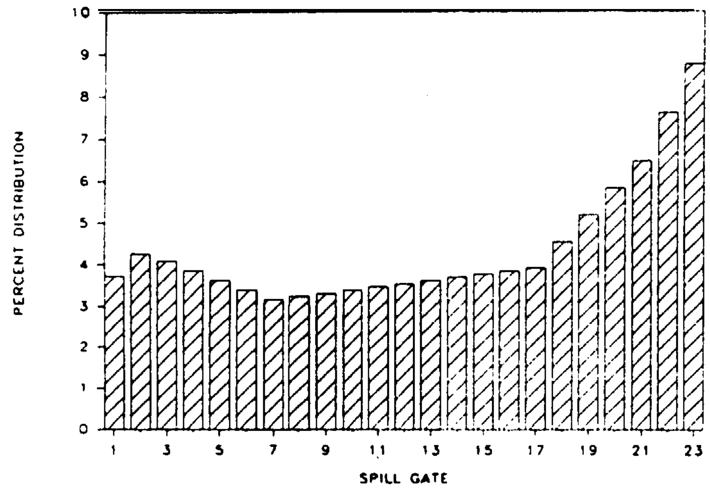


Figure H26. Horizontal distribution across the illway for Block 10. The Dalles Dam, 1985.

APPENDIX I: Empirical Slant Range Distributions

The empirical slant range distributions are calculated by the method described in Appendix D, Section D.5. The daytime and nighttime composite cumulative percentage distribution for all the turbines is given in Table 11 (spring) and Table 12 (summer). The composite spillway cumulative distributions for the spring and summer studies are presented in Table 13. The slant range distributions are plotted in Figures I1-I38 for all monitored turbine units by 12 h day (0800-2000 h) and 12 h night (2000-0800 h) for each block of the spring and summer studies along with season composites. Turbine Unit 22 is not included since generally too few detections occurred for block distributions to be created. Spillway distributions by spill gate for the spring and summer studies are given in Figures I39-I42.

Table Il. Seasonal composite of cumulative vertical distributions at the powerhouse for day and night, all units combined during the spring study. The Dalles Dam, 1985.

Range (Ft)	Day Cum %	Night Cum %
10	0	0
11	0.418	0.178
12	0.485	0.485
13	0.646	0.886
14	0.788	1.110
15	0.788	1.320
16	1.007	1.52s
17	1.007	1.832
18	1.157	1.949
19	1.157	1.949
20	1.195	2.185
21	1.479	2.811
22	1.692	3.206
23	1.784	3.390
24	2.014	3.863
25	2.014	4.163
26	2.092	4.459
27	2.121	4.941
28	2.325	5.330
29	2.406	5.801
30	2.547	6.409
31	2.634	6.800
32	2.902	7.327
33	2.971	7.739
34	3.034	8.465
35	3.156	8.953
36	3.211	9.454
37	3.320	10.052
38	3.320	10.052
39	3.576	11.270
40	3.664	12.134
41	3.801	12.716
42	3.924	13.553
43	4.044	14.303
44	4.233	15.119
45	4.385	16.047
46	4.521	17.000
47	4.753	17.851
48	4.890	18.726
49	5.122	19.624
50	5.389	20.482

Cont'd:

Range (Ft)	Day Cum %	Night Cum %
51	s.709	21.554
52	5.922	22.509
53	6.260	23.833
54	6.623	24.990
55	7.080	26.362
56	7.584	27.648
57	7.584	27.648
58	8.201	29.339
59	10.026	32.979
60	11.383	34.736
61	13.185	36.626
62	15.645	38.151
63	18.608	40.076
64	22.088	42.464
65	2s.997	44.99s
66	30.027	47.759
67	34.632	so.112
68	39.504	52.921
69	44.408	56.034
70	49.084	59.039
71	54.019	62.196
72	59.158	65.658
73	64.240	69.028
74	69.454	72.414
75	74.167	75.762
76	74.167	75.762
77	78.373	79.590
78	86.461	86.353
79	89.687	89.076
80	92.791	91.77s
81	95.502	94.220
82	97.473	96.578
83	98.746	98.288
84	99.427	99.286
85	99.852	99.872
86	99.990	99.984
87	100.000	100.000
88	100.000	100.000
89	100.000	100.000
90	100.000	100.000

Table 12. 'Summer composite of cumulative vertical distributions at the powerhouse for day and night, all units combined during the summer study. The Dalles Dam, 1985.

Range (Ft)	Day Cum %	Night Cum %	Cont'd: Range (Ft)	Day Cum %	Night Cum %
10	0	0	51	35.082	47.958
11	0.397	0.543	52	36.487	49.238
12	1.008	1.290	53	38.067	50.917
13	1.944	2.426	54	39.845	52.464
14	2.259	3.211	55	41.471	53.939
1s	2.908	4.029	56	43.374	55.843
16	3.688	4.975	57	43.374	55.843
17	4.313	5.762	58	45.239	57.619
18	5.146	7.141	59	49.498	61.677
19	5.146	7.141	60	51.77s	63.880
20	5.936	8.623	61	53.767	66.298
21	7.531	10.941	62	56.041	68.416
22	8.231	12.453	63	58.081	70.515
23	8.935	13.726	64	60.251	72.566
24	9.814	15.35s	65	62.433	74.684
2s	10.590	16.638	66	64.746	76.537
26	11.288	17.918	67	66.946	78.406
27	12.319	19.307	68	69.180	80.195
28	13.241	20.829	69	71.586	82.018
29	14.299	22.074	70	73.993	83.479
30	14.997	23.460	71	76.200	85.271
31	15.819	24.704	72	78.178	86.837
32	16.758	25.865	73	80.183	88.390
33	17.376	26.951	74	82.704	89.946
34	17.889	28.166	75	85.013	91.532
3s	18.546	29.220	76	85.013	91.532
36	19.239	30.460	77	87.648	92.976
37	20.009	31.581	78	92.239	95.512
38	20.009	31.581	79	94.258	96.733
39	20.970	32.882	80	96.098	97.956
40	22.556	34.989	81	97.656	98.865
41	23.335	36.119	82	99.039	99.498
42	24.171	37.413	83	99.800	99.874
43	25.043	38.568	84	99.964	99.991
44	26.098	39.736	85	99.99s	100.000
45	27.374	40.876	86	100.000	100.000
46	28.590	42.005	87	100.000	100.000
47	29.821	43.210	88	100.000	100.000
48	31.336	44.210	89	100.000	100.000
49	32.429	45.204	90	100.000	100.000
so	33.703	46.696			

Table 13. Seasonal composite of vertical distribution at the spillway, all gates combined during spring and summer, The Dalles Dam, 1985.

RANGE (Ft)	SPRING CUM %	SUMMER CUM %
4	0	0
5	0	0.228
6	0	1.058
7	0	2.819
8	2.445	6.087
9	3.848	11.089
10	7.374	14.356
11	11.245	18.812
12	15.261	22.724
13	19.528	26.824
14	21.494	31.17s
1s	36.709	34.645
16	49.724	38.699
17	57.190	42.169
18	63.699	44.746
19	68.717	46.936
20	72.468	so.122
21	75.827	52.160
22	79.20s	54.061
23	82.175	56.350
24	85.239	58.624
2s	88.682	60.080
26	90.104	62.169
27	92.079	63.240
28	93.822	64.746
29	95.208	65.708
30	96.143	73.103
31	96.321	82.689
32	98.049	91.603
33	99.360	96.783
34	100.000	99.828
35	100.000	100.000

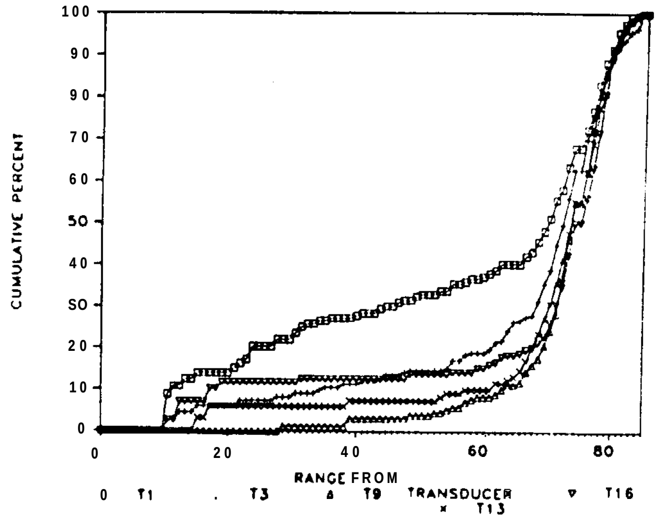


Figure Il. Daytime empirical slant range vertical distributions for each unit at the powerhouse for Block 1. The Dalles Dam, 1985.

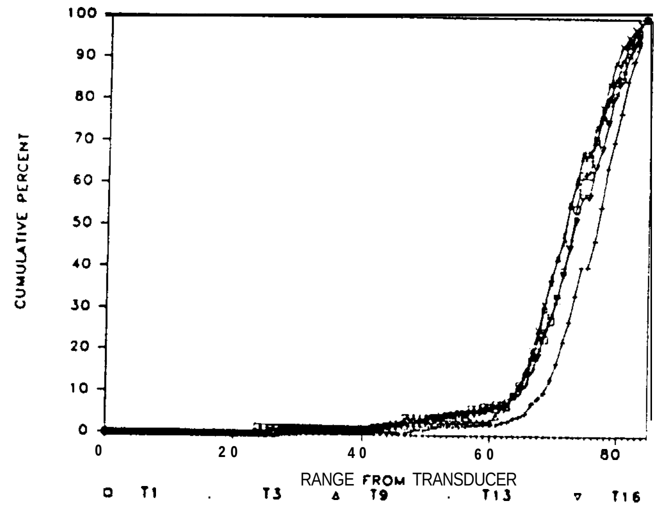


Figure 13. Daytime empirical slant range vertical distributions for each unit at the powerhouse for Block 2. The Dalles Dam, 1985.

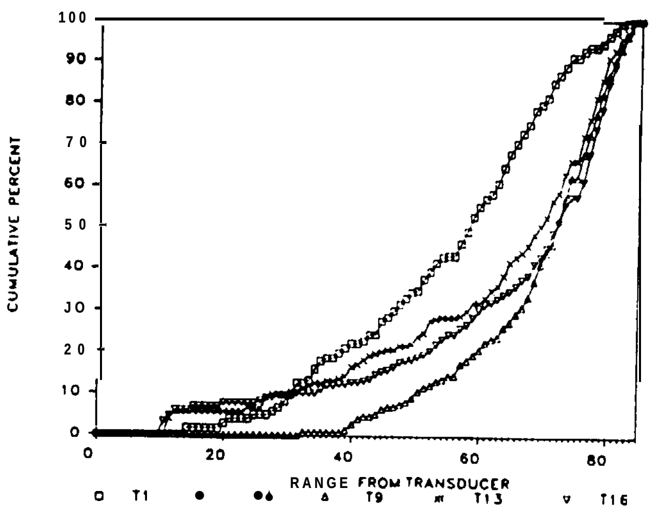


Figure 12. Nighttime empirical slant range vertical distributions for each unit at the powerhouse for Block 1. The Dalles Dam, 1985.

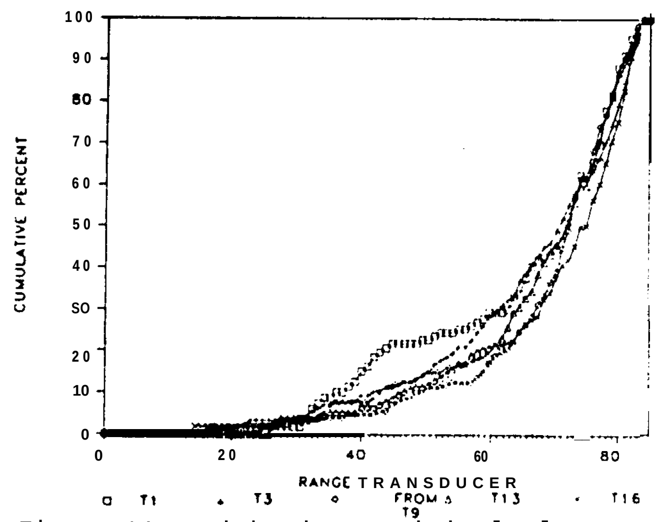


Figure 14. Nighttime empirical slant range vertical distributions for each unit at the powerhouse for Block 2. The Dalles Dam, 1985.

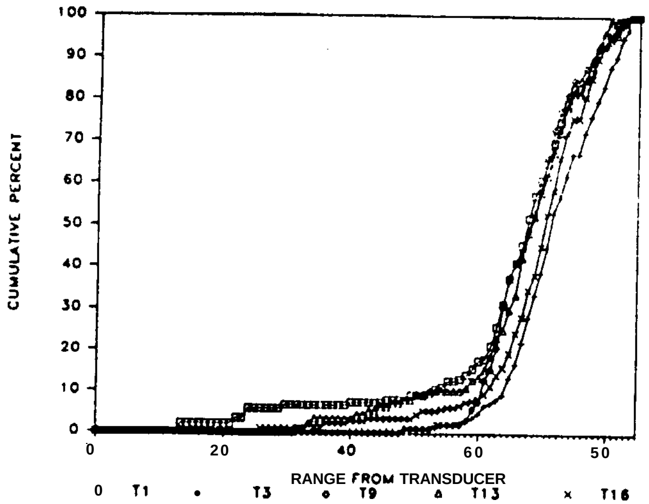


Figure IS. Daytime empirical slant range vertical distributions for each unit at the powerhouse for Block 3. The Dalles Dam, 1985.

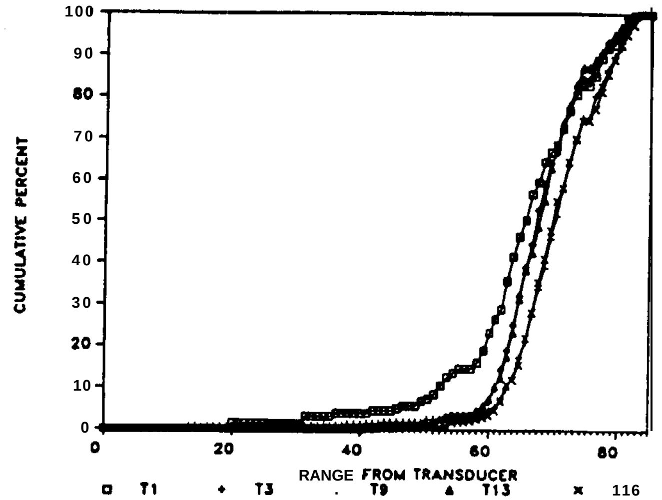


Figure 17. Daytime empirical slant range vertical distributions for each unit at the powerhouse for Block 4. The Dalles Dam, 1985.

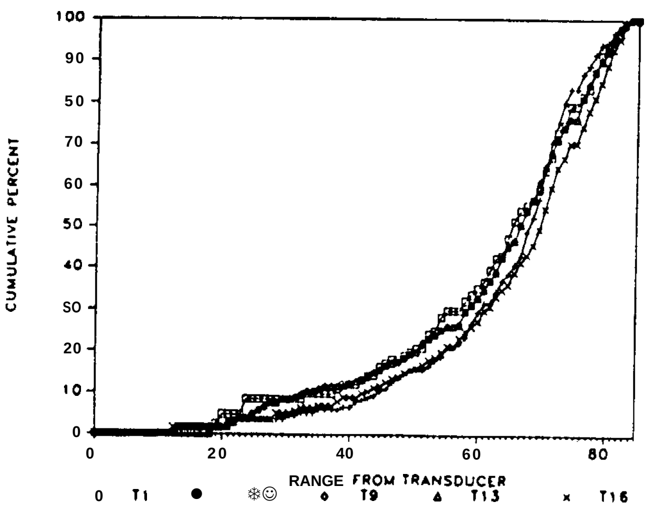


Figure 16. Nighttime empirical slant range vertical distributions for each unit at the powerhouse for Block 3. The Dalles Dam, 1985.

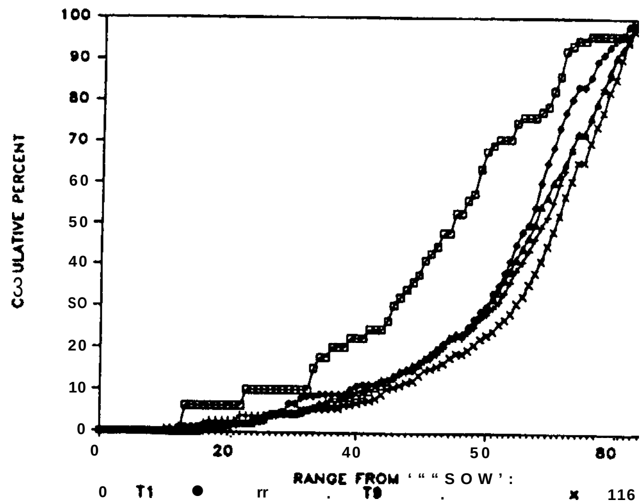


Figure 18. Nighttime empirical slant range vertical distributions for each unit at the powerhouse for Block 4. The Dalles Dam, 1985.

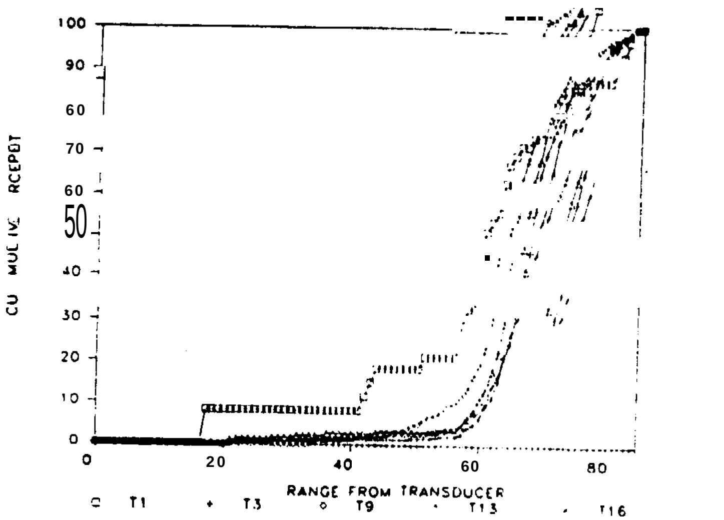


Figure 19. Daytime empirical slant range vertical distributions for each unit at the powerhouse for Block 5. The Dalles Dam, 1985.

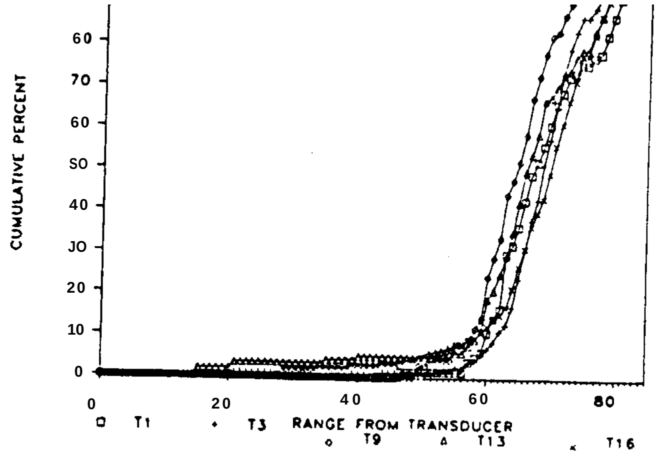


Figure Ill. Daytime empirical slant range vertical distributions for each unit at the powerhouse for Block 6. The Dalles Dam, 1985.

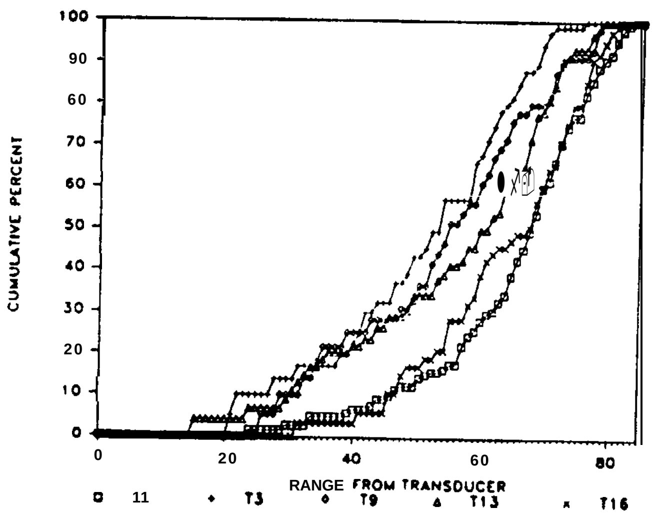


Figure 110. Nighttime empirical slant range vertical distributions for each unit at the powerhouse for Block 5. The Dalles Dam, 1985.

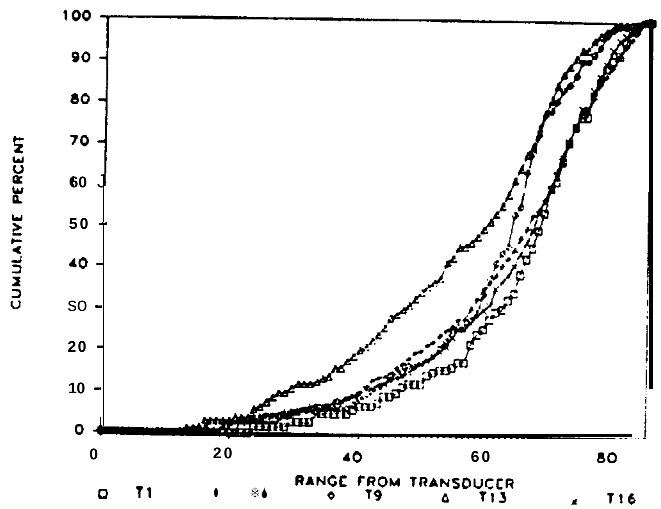


Figure 112. Nighttime empirical slant range vertical distributions for each unit at the powerhouse for Block 6. The Dalles Dam, 1985.

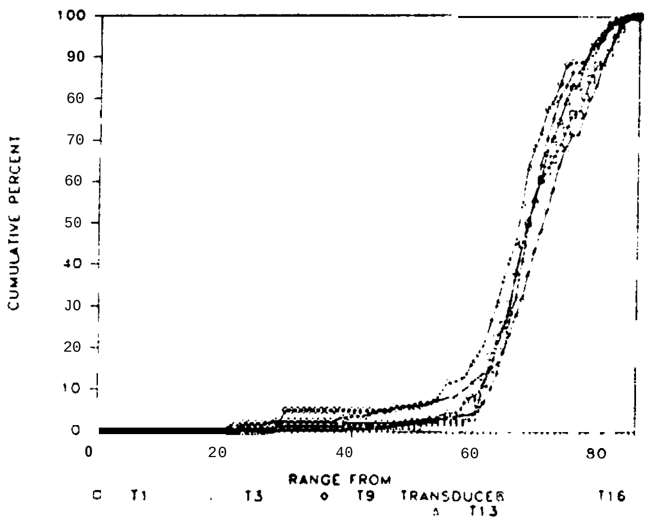


Figure 113. Daytime empirical slant range vertical distributions for each unit at the powerhouse for Block 7. The Dalles Dam, 1985.

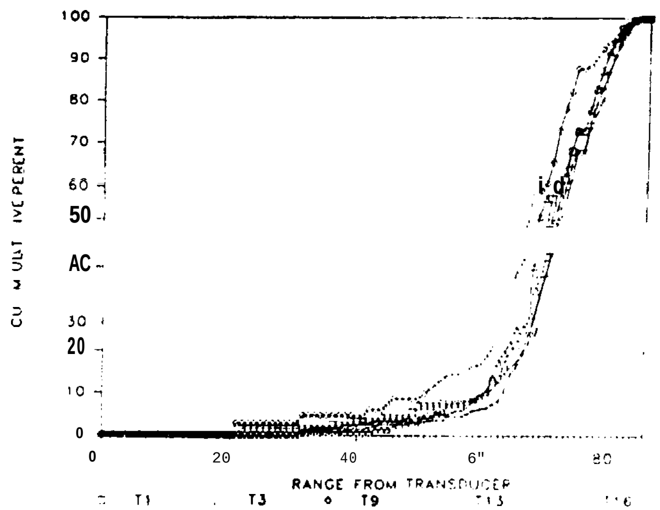


Figure 115. Daytime empirical slant range vertical distributions for each unit at the powerhouse for Block 8. The Dalles Dam, 1985.

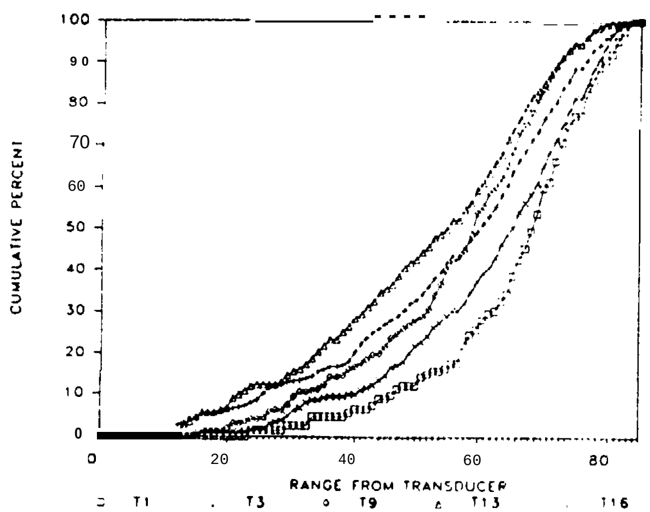


Figure 114. Nighttime empirical slant range vertical distributions for each unit at the powerhouse for Block 7. The Dalles Dam, 1985.

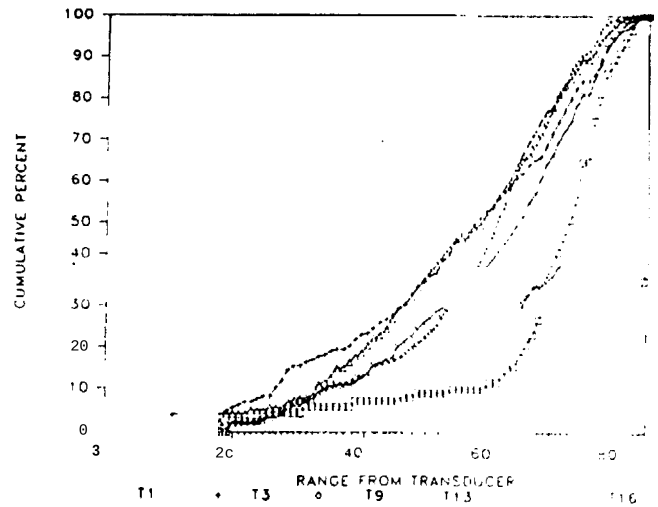


Figure 116. Nighttime empirical slant range vertical distributions for each unit at the powerhouse for Block 8. The Dalles Dam, 1985.

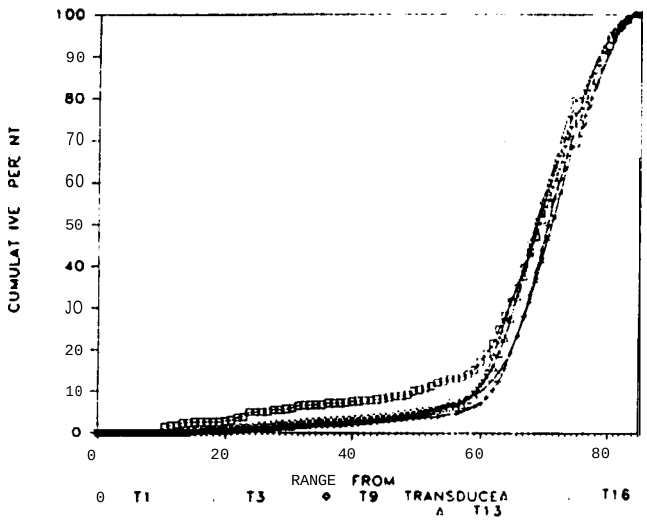


Figure 117. Seasonal daytime empirical slant range vertical distributions for each unit at the powerhouse. The Dalles Dam, 1985.

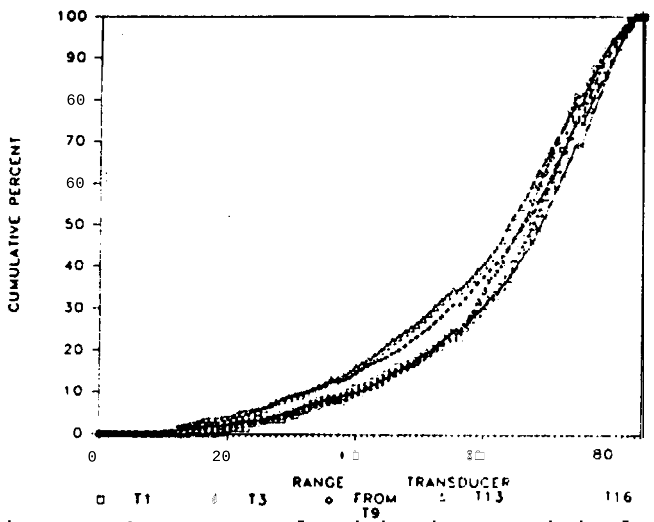


Figure 118. Seasonal nighttime empirical slant range vertical distributions for each unit at the powerhouse. The Dalles Dam, 1985.

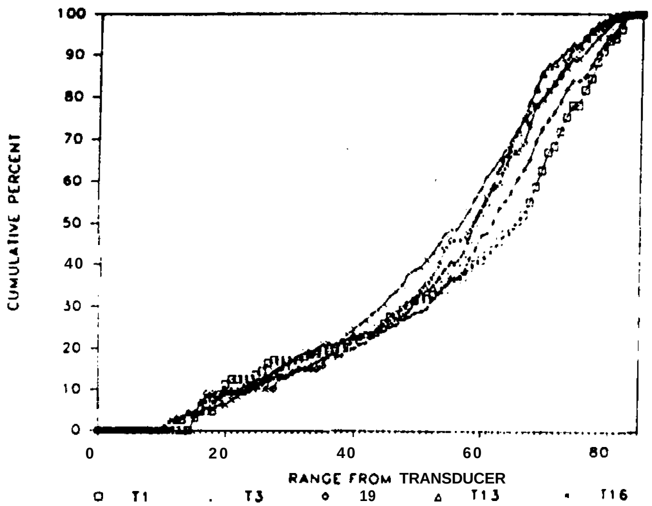


Figure 119. Daytime empirical slant range vertical distributions for each unit at the powerhouse for Block 9. The Dalles Dam, 1985.

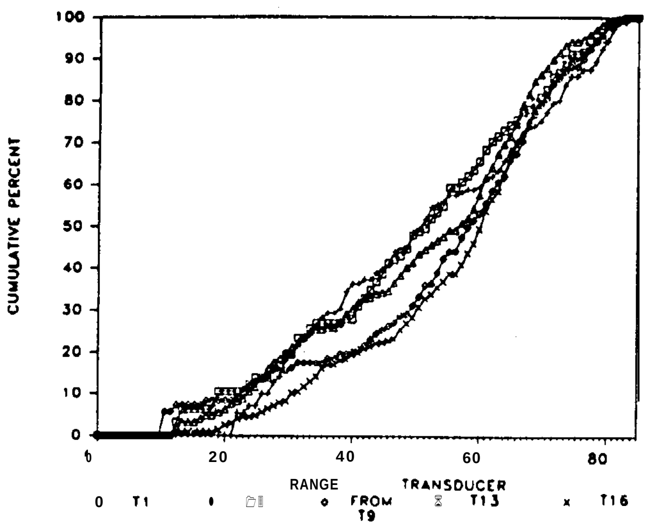


Figure 120. Nighttime empirical slant range vertical distributions for each unit at the powerhouse for Block 9. The Dalles Dam, 1985.

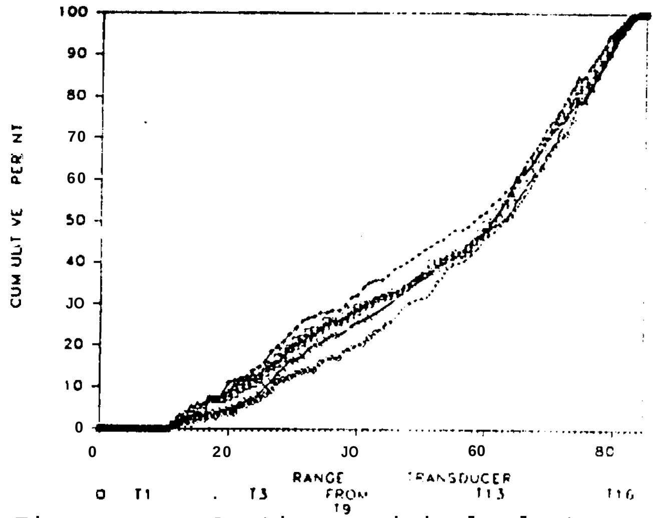


Figure 121. Daytime empirical slant range vertical distributions for each unit at the powerhouse for Block 10. The Dalles Dam, 1985.

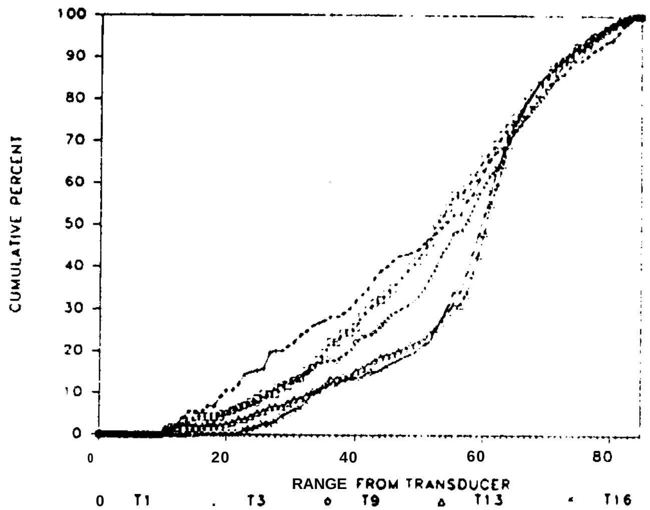


Figure 122. Nighttime empirical slant range vertical distributions for each unit at the powerhouse for Block 10. The Dalles Dam, 1985.

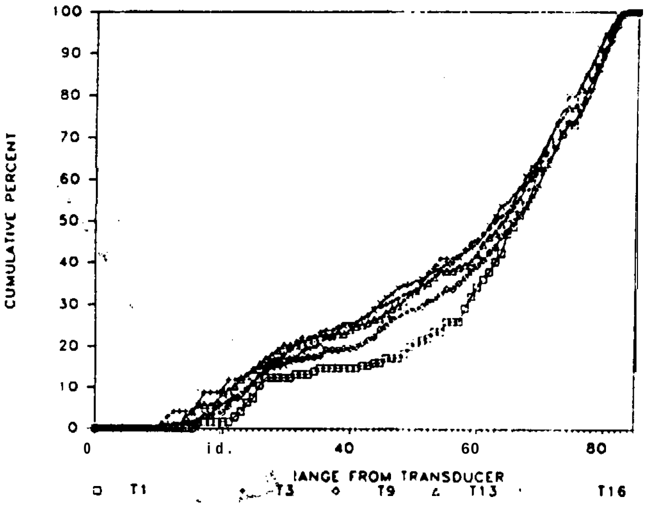


Figure 123. Daytime empirical slant range vertical distributions for each unit at the powerhouse for Block 11. The Dalles Dam, 1985.

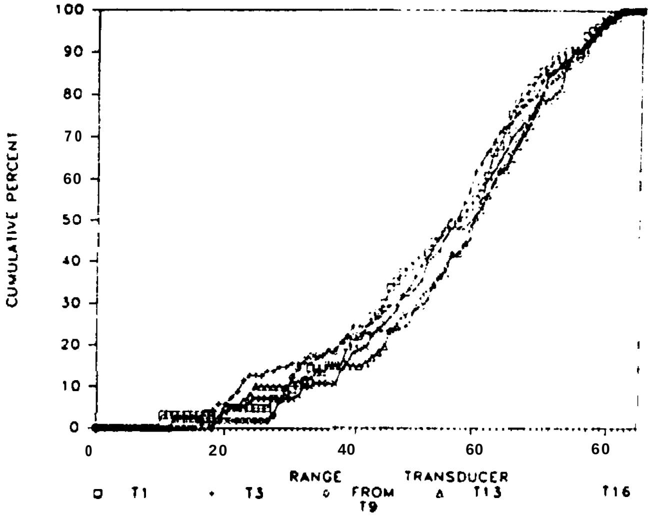


Figure 125. Daytime empirical slant range vertical distributions for each unit at the powerhouse for Block 12. The Dalles Dam, 1985.

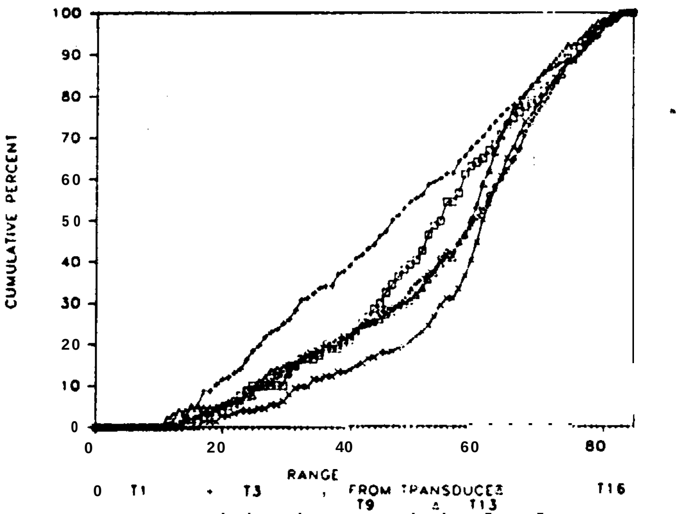


Figure 124. Nighttime empirical slant range vertical distributions for each unit at the powerhouse for Block 11. The Dalles Dam, 1985.

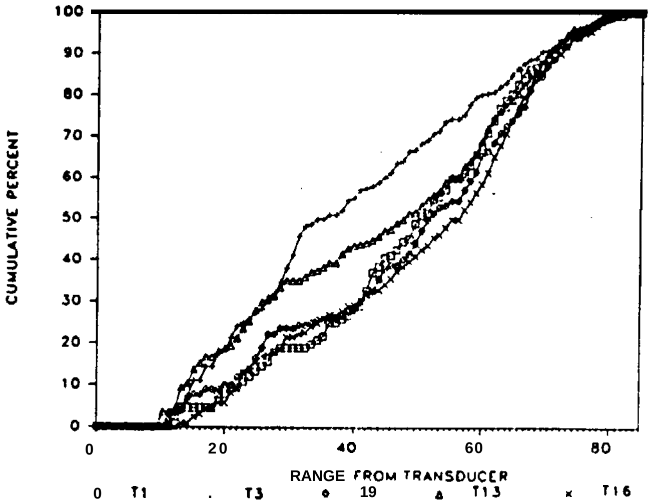


Figure 126. Nighttime empirical slant range vertical distributions for each unit at the powerhouse for Block 12. The Dalles Dam, 1985.

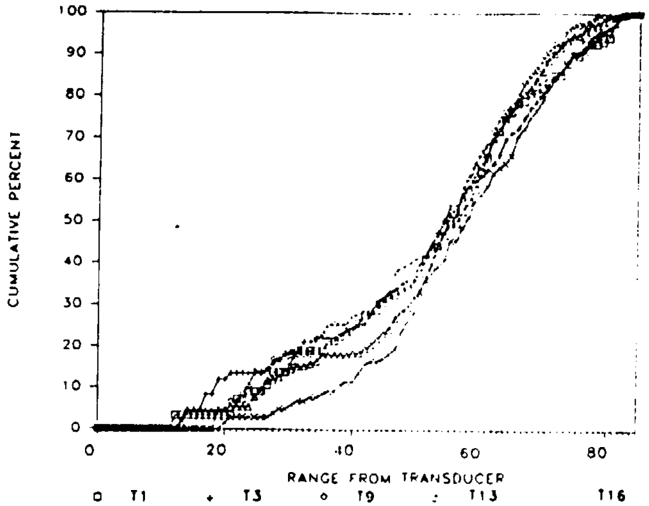


Figure 127. Daytime empirical slant range vertical distributions for each unit at the powerhouse for Block 13. The Dalles Dam, 1985.

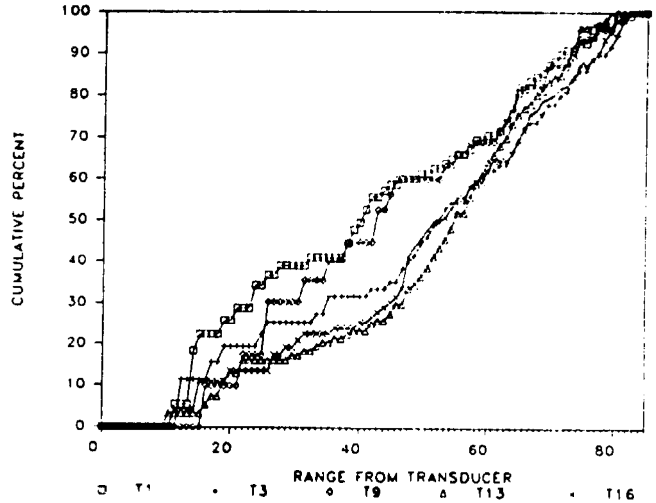


Figure 129. Daytime empirical slant range vertical distributions for each unit at the powerhouse for Block 14. The Dalles Dam, 1985.

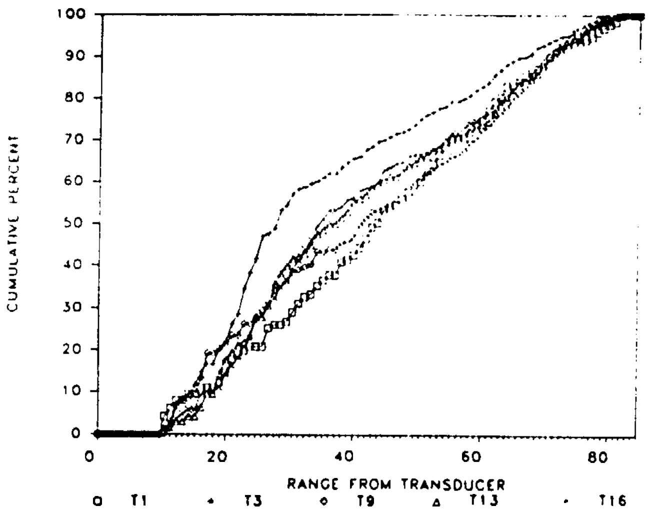


Figure 128. Nighttime empirical slant range vertical distributions for each unit at the powerhouse for Block 13. The Dalles Dam, 1985.

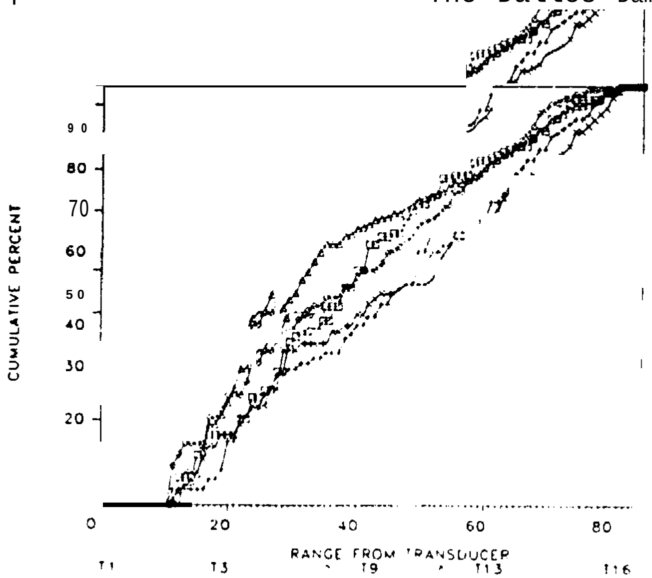


Figure 130. Nighttime empirical slant range vertical distributions for each unit at the powerhouse for Block 14. The Dalles Dam, 1985.

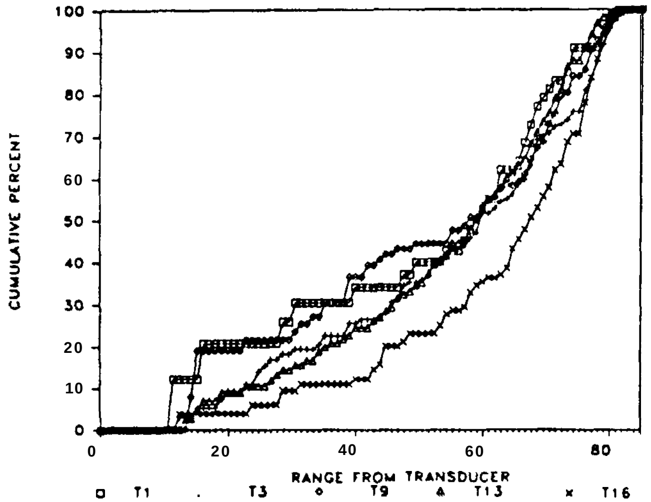


Figure 131. Daytime empirical slant range vertical distributions for each unit at the powerhouse for Block 15. The Dalles Dam, 1985.

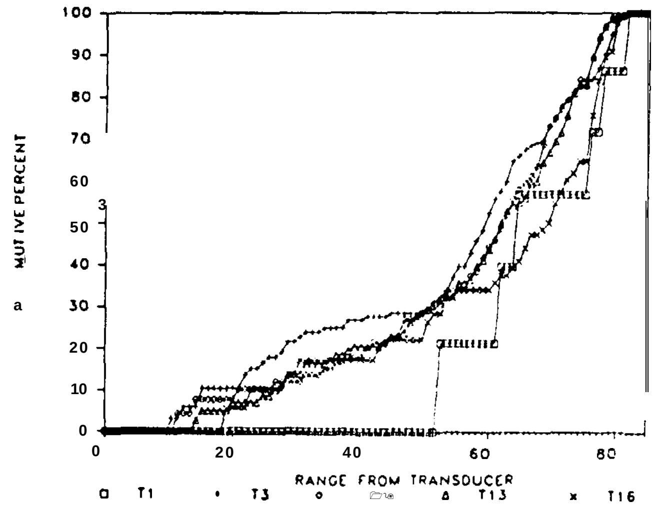


Figure 133. Daytime empirical slant range vertical distributions for each unit at the powerhouse for Block 16. The Dalles Dam, 1985.

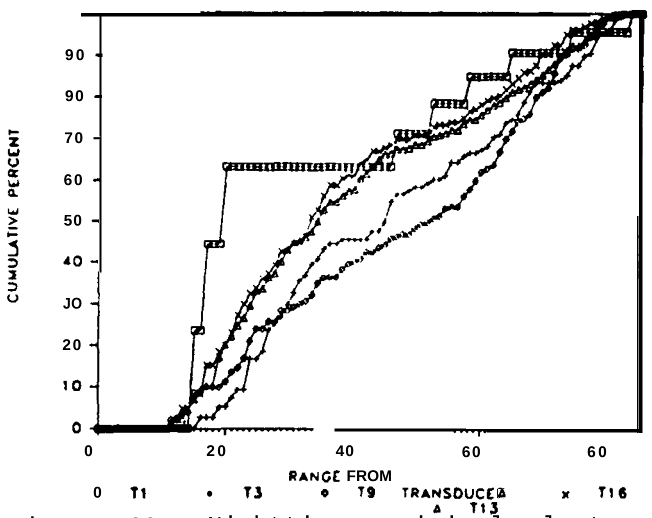


Figure 132. Nighttime empirical slant range vertical distributions for each unit at the powerhouse for Block 15. The Dalles Dam, 1985.

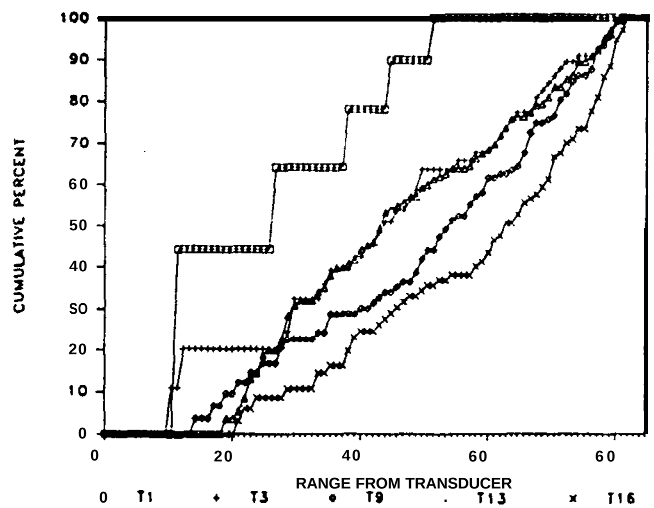


Figure 134. Nighttime empirical slant range vertical distributions for each unit at the powerhouse for Block 16. The Dalles Dam, 1985.

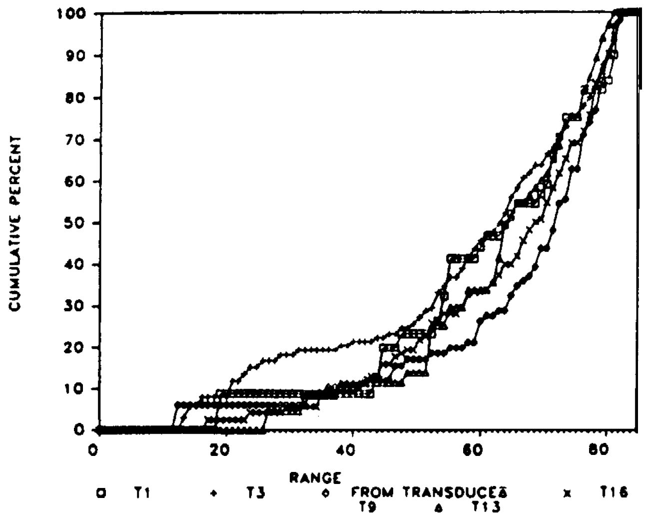


Figure 135. Daytime empirical slant range vertical distributions for each unit at the powerhouse for Block 17. The Dalles Dam, 1985.

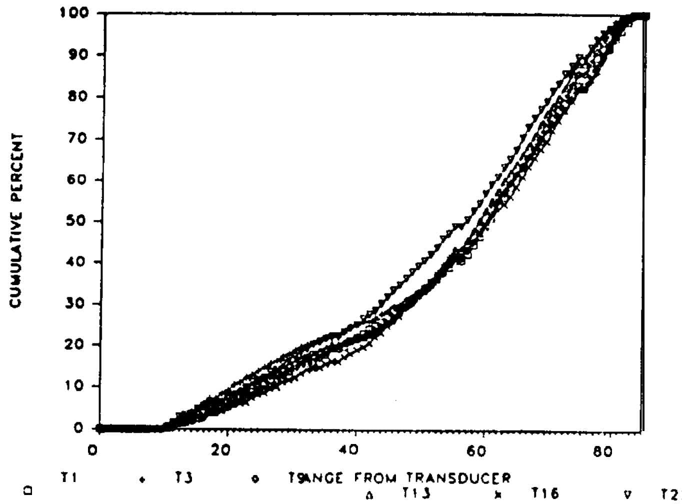


Figure 137. Summer seasonal daytime empirical slant range vertical distributions for each unit at the powerhouse. The Dalles Dam, 1985.

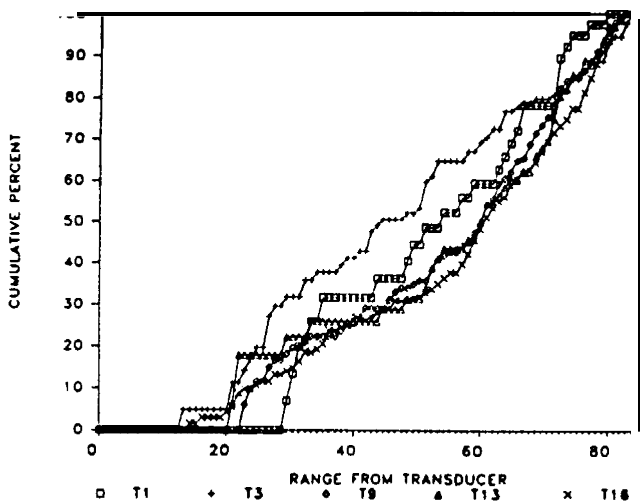


Figure 136. Nighttime empirical slant range vertical distributions for each unit at the powerhouse for Block 17. The Dalles Dam, 1985.

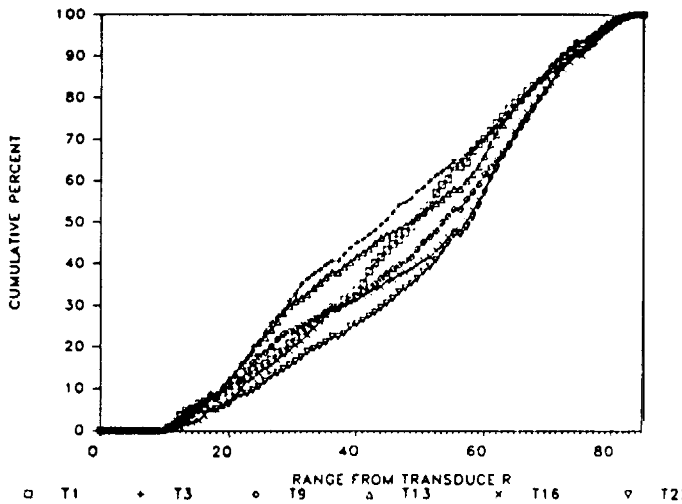


Figure 138. Summer seasonal nighttime empirical slant range vertical distributions for each unit at the powerhouse. The Dalles Dam, 1985.

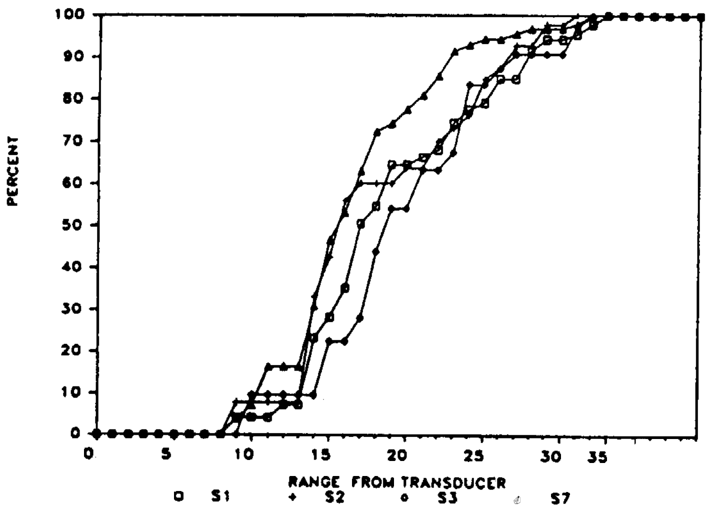


Figure 139. Spring empirical slant range vertical distributions across the spillway for gates 1, 2, 3, and 7. The Dalles Dam, 1985.

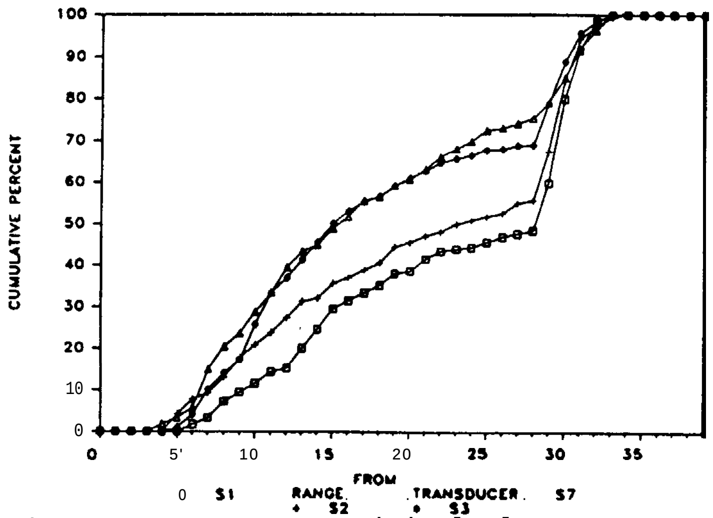


Figure 141. Summer empirical slant range vertical distributions across the spillway for gates 1, **2,** 3, and 7. The Dalles Dam, 1985.

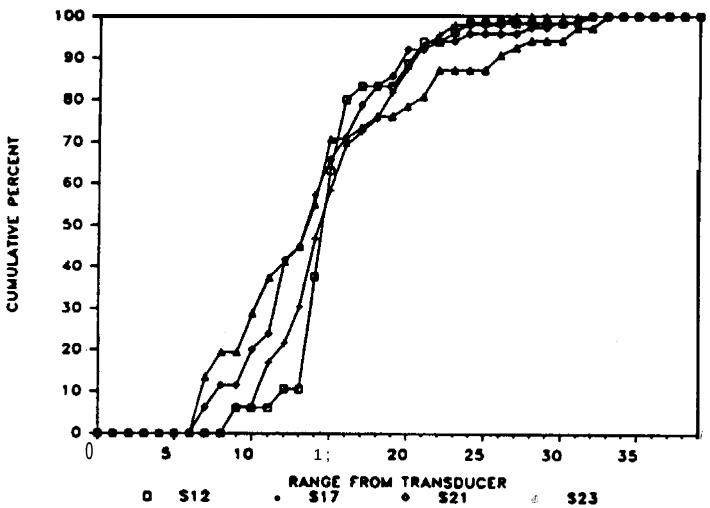


Figure 140. Spring **emprical** slant range vertical distributions across the spill way for gates 12, 17, 21, and 23. The Dalles Dam, 1985.

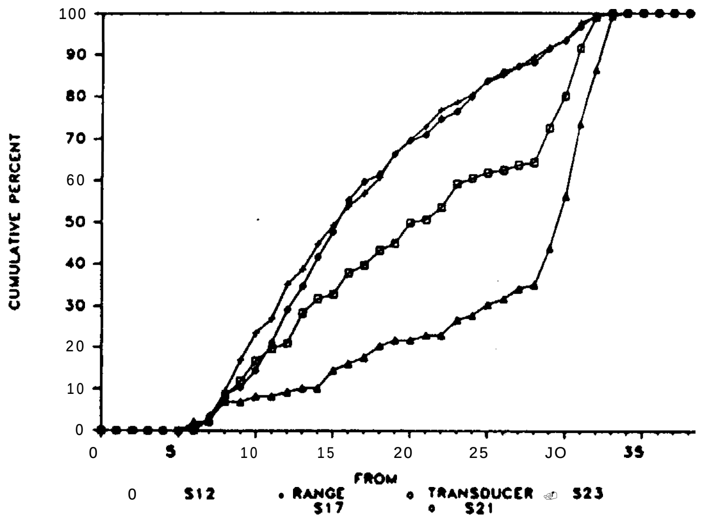


Figure 142. Summer empirical slant range vertical distributions across the spillway for gates 12, 17, 21, and 23. The **Dalles** Dam, 1985.

APPENDIX J: Comments and Responses to The Dalles Dam 1985 Hydroacoustic Report.

The final draft of this report was presented to the BPA which forwarded a copy to the Portland District of the Army Corps of Engineers. The Corps of Engineers submitted comments in writing for consideration in the preparation of this final report. To the extent practical, responses to verbal comments concerning this report have also been taken into consideration in the final report.

This appendix contains the comments received calling for revisions and/or explanations and our responses to these comments. BioSonics wishes to thank Doug Arndt and Edward Mains for the time and effort they devoted to comments on the final draft.

Comment A.l): There was spill during the period of time that sluiceway efficiency was determined. This spill influence is not accounted for in the calculations of sluiceway efficiency. Suggest that the authors review the 1982 ODFW report entitled, "Indexing of Juvenile Salmonids Migrating Past The Dalles Dam, 1982". This report includes an algorithm for determining sluiceway efficiency during spill conditions.

Response: Any comparison with this algorithm is only as good as the range in the data collected. In the example cited, the comparison is how the change in the level of spill affected spillway and sluiceway fish passage. The range of percent river spilled for the spring study period was 6.1% to 13.2% (24 h daily average) and 7.3% to 11.1% for the summer study period. Since the hydroacoustic data was collected over a very small range of spill levels, it would not be meaningful to compare this data to the indirect model presented. However, the overall average spillway and sluiceway effectiveness results could be compared with the model. This comparison is shown in the following table.

Table Jl. Bypass efficiency from hydroacoustic data and the ODFW prediction.

	Mean Percent Spill Flow	Percent Spill Fish Acoustic	Percent Spill Fish Predicted	Percent Spill and Sluice Fish Acoustic	Percent Spill and Sluice Fish Predicted
Spring	10.33	9.18	33	32.37	59
Summer	9.73	23.33	32	37.53	58

To better illustrate the range over which the hydroacoustic results are comparable to the model, Figures J1, J2 and J3 are presented. These figures show the relationship of spillway and (spillway + sluiceway) fish passage with the increase in spill level. Also the curves from the 1982 ODFW report are superimposed on the figures.

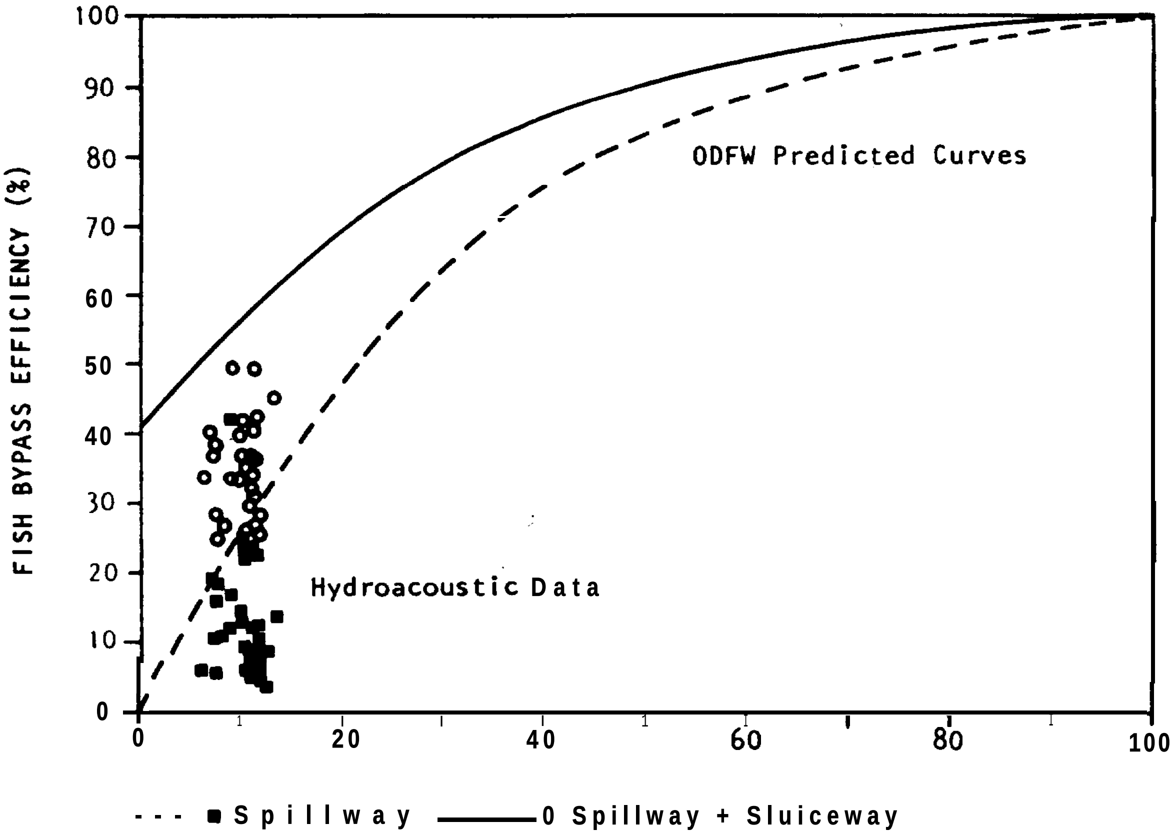


Figure **J1.** Comparison of the fish bypass efficiency between the hydroacoustic data and the ODFW predicted curves. Hydroacoustic data taken during the spring and summer 1985 at The Dalles Dam.

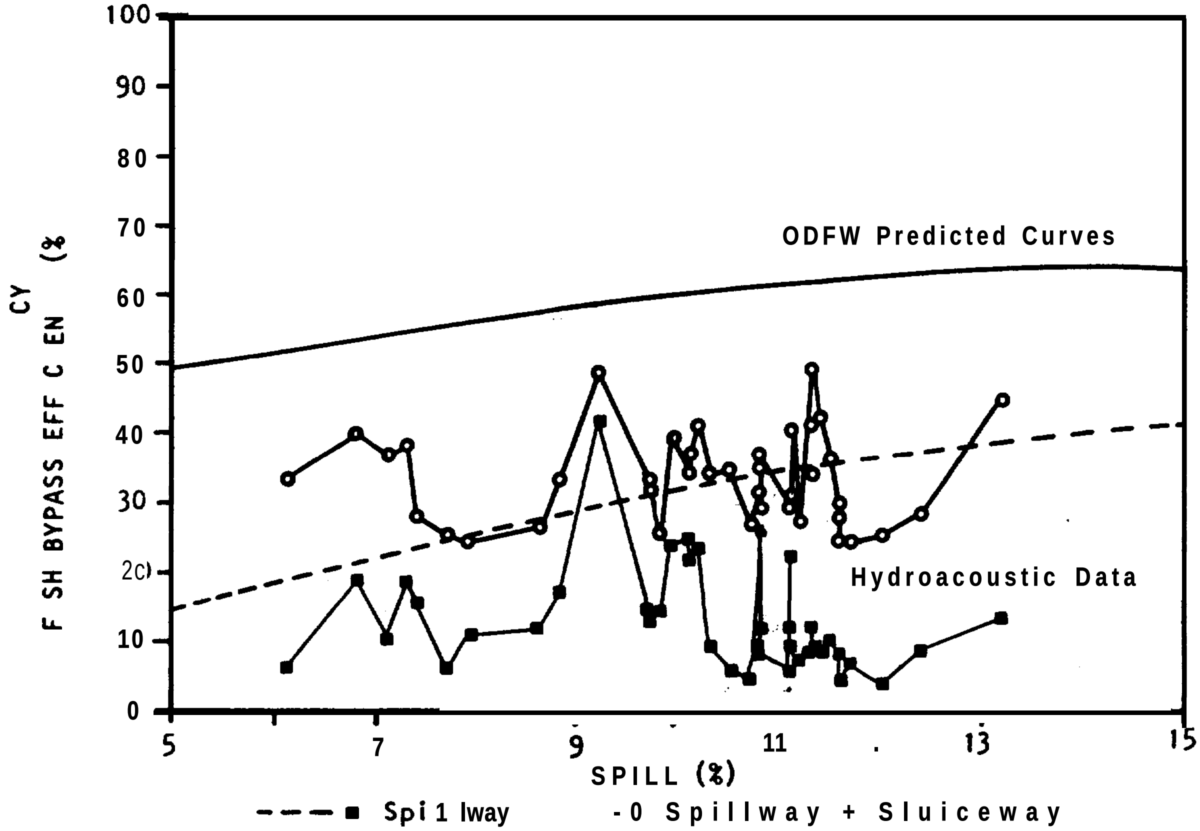


Figure J2. Expanded comparison of the fish bypass efficiency between the hydroacoustic data and the ODFW predicted curves. Iiydroacoustic data taken during the spring and summer 1985 at The Dalles Dam.

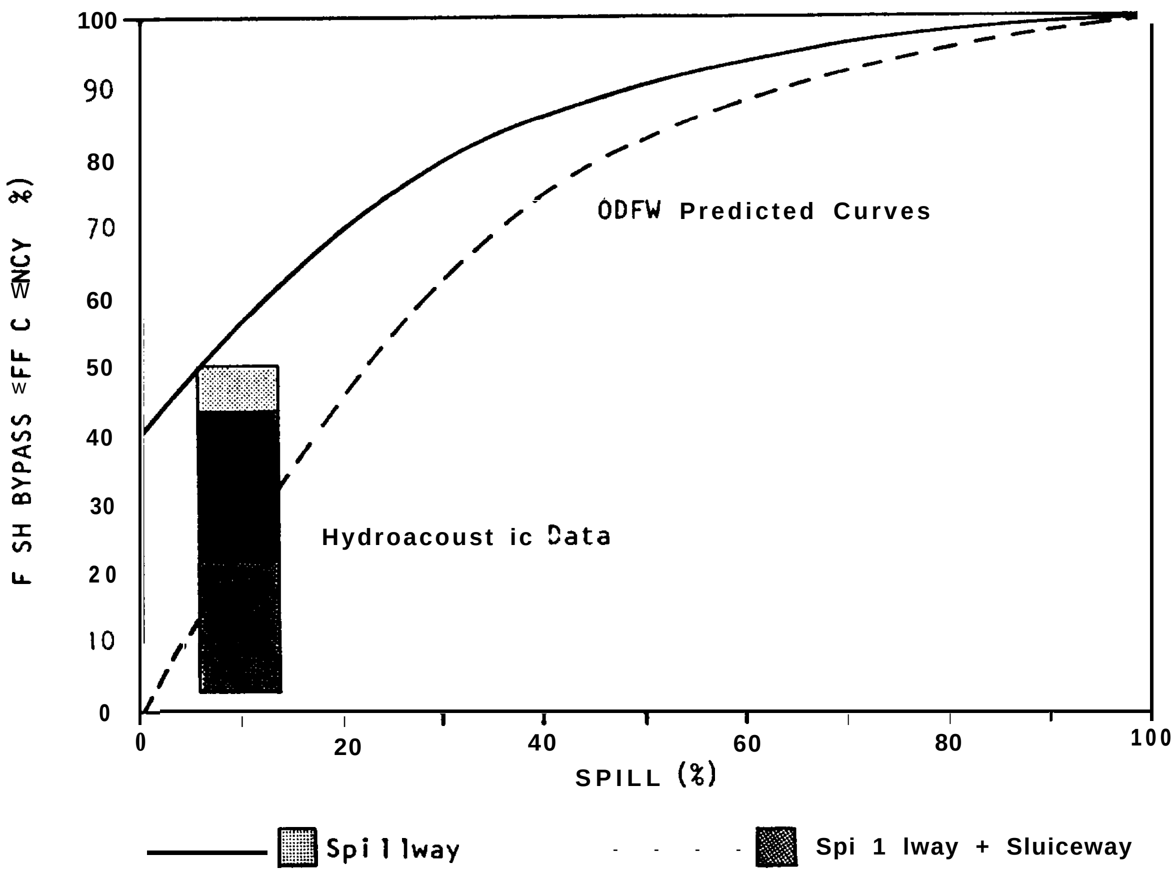


Figure J3. Range of the fish bypass efficiency from the hydro-acoustic data compared with the ODFW predicted curves. Hydro-acoustic data taken during the spring and summer 1985 at The Dalles Dam.

Comment A.2): On Page 14 the authors make the observation that Spill is more effective at passing fish during the summer than during the spring season. The following clarification should include the fact the spill was limited to 10 h during the daylight hours. This is a time when fall migrating fish are more actively migrating than are spring fish and would probably be more affected by spill.

Response: With respect to the differences between the fall migrating fish and the spring migrating fish, the change in vertical distribution of the fish seemed to be the most important result. This point was well emphasized throughout the report. However, the daytime/nighttime results showed the fish passed primarily during the daytime hours for the summer study period. During the spring study period, the fish passed the project continuously throughout the 24 h period. This would suggest the change in the die1 distribution during the summer season could increase the effectiveness of daytime spill on a 24 h daily average basis. This will be pointed out more clearly in the final report in not only the die1 section but also in explaining the overall differences between the spring and summer Study periods.

This shift in the die1 distribution has also been seen at other projects on the Columbia River. The nighttime fish passage at Rock Island Dam in 1984 increased over similar time periods in 1983. This change in the die1 distribution along with changes in spill configurations resulted in a substantial increase in the project spill effectiveness.

Comment B.): Throughout the report the authors compute efficiencies/effectiveness and so forth using percentages (e.g., pg. 11,13,16). This method gives equal weight to days regardless of the number of fish passing on each of the days. I believe that a more meaningful technique would be to weight by fish count. This is of particular concern if the number of fish involved in the calculations vary much from day to day.

Response: This is a good comment if the objectives of the study were to determine the percent absolute magnitude of fish passing through the turbines, spillways and sluicegates for the entire season. However, that was not a specified contract objective and was not analyzed as one of our study objectives.

This information could easily be estimated by first multiplying the daily percent passage estimates by the percentage daily run timing. After summing up and re-normalizing, the seasonal percent magnitude of fish passage through turbines, spillways and sluice gates can be determined.

Comment C.): Somewhere in the report there should be some actual fish counts rather than just percentages. This would allow users of the report to make use of the data for additional analyses.

Response: The main objectives of this study were to compare the effectiveness of passing downstream migrants through spillway, sluiceway and turbines. To ensure accuracy in making these comparisons, it is imperative that the relative detectability is constant between the three passage locations. However, it is not necessary to determine absolute fish numbers when making relative comparisons between different locations, daytime/nighttime, or spatial and temporal distributions. If absolute numbers of fish were of concern, knowledge of the acoustic target strength of the fish would be necessary to define the actual sample volume. since the contract did not specify absolute fish numbers, only relative numbers were calculated and relative numbers were included in the report.

Comment **D.)**: In many of the correlations such as El and E2 there is an assumption that the curve goes through the origin. This results in a much better fit to the curve than would be expected by the observed data points. For example, in Figure El the R is 0.98. Without the assumption that the curve goes through the origin the correlation would be nearly 0.0. while it is intuitively possible to say that with 0 spill there will be 0 fish passage through the spillway, the removal of this assumption will show the lack of fit of the observed data points. The real problem probably lies in a lack of linearity in the curve.

Response: This comment is absolutely true. The intent was not to deceive the reader, but rather to be consistent with the way data has been presented in previous mid-Columbia River hydroacoustic reports.

Comment **E.)**: Pg. 43-46. The horizontal distribution for unmonitored units is interpolated and shown on the figures. In a report of this nature I can see no reason for making these interpolations. Suggest that the authors simply show the data for the monitored units.

Response: The horizontal distribution includes the unmonitored locations (interpolated from the monitored units) since the passage rates through these locations are needed to determine the actual effectiveness of fish passage through the spillways, sluiceways and turbines. since these interpolated values were used to estimate the effectiveness results, it was determined that it was also appropriate to present these interpolations.